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Formal Discipline

FORMAL DISCIPLINE

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FORMAL DISCIPLINE

Introduction

Meaning of the Doctrine. Arising sometimes out of *a priori* philosophy, and at other times out of naive observations on actual life, there has for a long time existed the notion that mental power was a sort of entity which could be turned in any direction, to the solution of any problem. This is indicated by such phrases as, "He is a man of ability," or, "He has had good mental training," or, "He was well disciplined in college," or "He has great intellectual power," or "He is a man of deep insight," or "unusual foresight." In all these classes there is no specification of the lines in which these abilities are sharp or effective, no peculiar specification being considered in the general statement. The same is commonly heard in describing people in other realms of expression, as, "He is a man of fine feeling," or "He is very sensitive," or "He is very appreciative or full of sentiment;" or still again in another general field, "He is a man of strong will," or "of great force."

From these more general affirmations concerning human character, there are numerous gradations toward the specific. For example, "He is a good reasoner," "an acute thinker," "a shrewd observer," or "He is a lover of the beautiful," or "is fond of history," or "has great courage." In all these it will be noticed that there is no particular line in which these capacities are said to be manifested. The question is not put: In what subjects is he an acute thinker, or of what sort of beautiful thing is he a lover, or in what phases of life is he courageous, *e. g.*, in fighting, or in facing an audience or a woman; or of what sort of history is he fond, or in what lines is he a good observer. Again the question may be more narrowly put: He is a good mechanic, but with what tools? She is a good musician, but on what instrument? She is a good painter, but

with what—water color, oil, or pastel? Now these narrow questions are not what the advocate of formal discipline puts. He takes the larger words as exponential of character, like "well-trained mind," and holds that the particular actions are simply the outcome in certain directions of that general mental attitude.

And the result on the side of education, both in theory and practice, is apparent. Any subject which exercises the student is as good as any other, or, if there is any difference, it is one of degree. The remoteness of the subject from the life which the student is to follow is of no importance, whether this remoteness relates to the subject matter, the method of getting that subject matter,or the accomplishment effected by the study. Though one were to be a Christian in adult life in morals and religion, the study of pagan literature was as generally helpful in that direction as the study of Jewish literature, for after all it gave the general things called "culture," "outlook." The same was held to be true of history, so that even yet modern history occupies a very subordinate place,if any at all, in most of the high schools, which are thinking more especially of the mental development of the student as opposed to the college which has more nearly in mind the nearness of practical life. Indeed, the great argument for the classics, for geometry, for algebra, in the older courses, and later for the introduction of botany, physics and astronomy, and still later for drawing, nature study and manual training, has been in more or less explicit form the dogma of formal discipline, *i. e.*, that each of these are generally helpful to the mind as such, or, one grade removed from this, are productive of ready memory, keen perception, accurate reason, lively imagination. Such words or phrases as "intellectual power," "moral training," "mental force," "fibre," "taste," "character," "disposition" are the ends of school training.

*Extent of Belief in and Practice According to theDoctrine.*The Greeks held in theory, as well as in practice, to the theory of general training. Plato conceived of a kind of dance which would not only bring out all the desirable characteristics of the body, but likewise those of the mind. Their whole training

would be largely of the character called culture by us today. However, the life of the Greek referred to by Plato, as by Aristotle, was that of one of the upper classes only, who was supported by slaves, and was thus allowed to disport himself in an easy and untechnical way in politics or art, or conversations about everything under the sun. Thus there was a closer unity between the matter and method of the school and of after life than at first appears. But with the appearance of Scholasticism, formal discipline started on a career of centuries. All one needed was a training in logic, in intellectual gymnastics, and from this source of knowledge, the inner consciousness, could be spun out all good and worthy things. This notion fixed logic in the course for all these passing years. Latin and the classics generally were studied in the middle ages for the knowledge they contained, and that only as mentioned above; but as the other tongues developed literatures, they were continued partly by the force of traditional inertia, and partly on account of their supposed disciplinary value. Coming on to our own day, the advocates of even such seemingly practical subjects as manual training, including cooking, sewing, and gardening, either in deference to the customary justification of school subjects, or to some really supposed logical connection, take special pains to say that these things are not introduced for their practical value; far from it, they are simply to achieve more effectively than did the old list those points of general culture, and the whetting up of the so-called faculties, as memory, imagination, reason, etc. The advocates of nature study say that it helps to better observation, in respect to both the number of things observed and the acuteness of the process. Their favorite phrase is, "It trains in observation," and their general position is that it does not make much, if any, difference what is observed, so long as that mental function is performed. With some view to the study of the law in my earlier days, I was repeatedly advised to study mathematics that my mind might be trained into accurate, well balanced, logical and exhaustive methods. On the other side, law is often studied in general courses for its cross effects in avenues in no ways legal.[1]

[1]Leland Stanford, Jr., University lately opposed an Act before the California Legislature to free her graduates in law from the bar examinations on the ground that her purpose was not directly to prepare lawyers.

This position on formal discipline is clearly revealed in all that very large class of people in this country who send their children to private military schools, which are in no sense preparatory to West Point. These parents are avowedly not thinking of their sons becoming warriors, and it is often the very boys who are sent to these schools, who are in no special mood for soldierly service and care little for the drills which they are compelled to undergo. But the patent declarations of these schools are that the students learn respect for law, obedience, promptness, attention to duty and to details, courage, patriotism, and all the host of things which skill in precise conformity to law and authority bring. The same principle lies at the base of much of the militarism of the public schools in their marching here and there, keeping in line, "heads up, eyes to the front," the slipping, sliding and starting at "one, two, three," etc., *ad infinitum*. So also in many institutions for orphans and the like, in which the lights go out at this time, rising bells ring at another, everything working according to machinery and mathematics. All this is done not for the reason or even expectation that the children will do these same things in after life; for the leaders of these schools show by their own actions, as well as by confession, that these are not the ways of life. But such training teaches the children to do the things they are not to do in the right way, at the right time, etc. Indeed, there are two implicit articles in this creed: first, that the child will learn to do the right thing—I mean here the right act, *e. g.*, going out of a theater properly,—by *not* doing that thing, but something else; second, that the child will be best prepared for certain things not only by not doing those things, but indeed by doing nothing about them or at all related to them. That is, by this life of negation, greater capacity will be acquired for positive action later on. I wish to repeat for emphasis that whatever good or evil exists in the convents, cloistral schools, and all others with walls about them, is a direct outcome of the notion or doctrine of formal discipline, stated from its negative side. It clearly implies that the building up of the organism in one way—for living things keep changing and growing—will be the most effective preparation

for actions depending on habits in no way comparable to those earlier formed.

A later form of the doctrine of formal discipline, approved in high circles, is in connection with the new system of electives in our colleges and universities. The administrators of these institutions disavow any connection with professional schools or trade schools as such, holding that it does not make much difference what the student takes so that he takes it well; *i. e.*, it makes no difference what his business or calling after he leaves the university will be, a thorough course in one thing being about as good as another. There is apparently the belief that this one elected subject, rightly pursued, will give the student something which will carry over into any or all fields whatsoever.

The following citations are given to illustrate the statements just made and to indicate the use made of the word "discipline."

The type of instruction should be disciplinary rather than practical.[1]

The mind is chiefly developed in three ways: by cultivating the powers of discriminating observation; by strengthening the logical faculty; and by improving the powers of comparison. As studies in languages and in the natural sciences are best adapted to cultivate the habit of observation; as mathematics are the traditional training of the reasoning faculties, so history and its allied branches are better adapted than any other studies to promote the invaluable mental power which we call judgment.[2]

This same committee, including among others, Charles W. Eliot, Wm. T. Harris, and James B. Angell, say:

On the theory that all the subjects are to be considered equivalent in educational rank for the purpose of admission to college, it would make no difference which subjects he had chosen from the programme—he would have had four years of strong and effective mental training.[3]

To this James H. Baker objects as it ignores "Philosophy, Psychology, and the Science of Education."(3)

Arithmetic, if it deserves the high place it conventionally holds in the educational system, deserves it mainly on the ground that it is to be treated as a *logical* exercise.[4]

[1]W. H. Payne, *Contributions to the Science of Education*, p. 50.

[2]Report of the Committee of Ten, U. S. Bureau of Education, 1892, p. 168.

[3]Report of the Committee of Ten, U. S. Bureau of Education, 1892, p. 87.

[4]Bain, *Education as a Science*, p. 152.

Arithmetic, when taught with this in mind—the notion of logical method—gives to the pupil not knowledge of facts alone, but that which transcends such knowledge, namely, power.[1]

Value of technical instruction, that which regards hand and eye training *per se* as an essential part of human culture.[2]

During dictation (exercises) the child can get no chance to play, sleep, be idle, or do mischief. The process is the best and most perfect drill for order.[3]

The fiction of formal education (Bildung) must be given up. In general there exist simply as many kinds of formal education as there are essentially different phases of intellectual employment.[4]

For the training of this power of observation, it does not matter what subject the child studies, so that he study something thoroughly in an observational method. If the method be right, it does not matter among the numerous subjects well fitted to develop this important faculty, which he choose or which be chosen for him.[5]

Mathematics does furnish the power for deliberate thought and accurate statement, and to speak the truth is one of the most social qualities a person can posess.[6]

Mathematics no more teaches reasoning in the ordinary sense than traveling by railroad fits a man for exploring in Central Africa.[7]

Nothing is better for developing gradually, and methodically, all the intellectual faculties of children than the study of grammar and literature. They exercise memory, sagacity, taste, judgment—under all its forms.[8]

H. Sidgwick quotes the above and assents to it in essays on a Liberal Education, but feels it somewhat too sweeping.

By cultivating the Greek and Roman languages we acquire skill in all mental operations. The study of mathematics ranks next in importance and furnishes an excellent training to the faculties.[9]

[1]Smith, *The Teaching of Elementary Mathematics*, p. 26.

[2]Fitch, *Educational Aims and Methods*, p. 158.

[3]Manual for Public School, 1850, p. 158.

[4]Rein, *Outlines of Pedagogics*, p. 42.

[5]Charles Eliot, *Forum*, 1892, p. 428.

[6]Dutton, *Social Phases of Education*, p. 30.

[7]J. M. Wilson, Master of Rugby, *Essays on Literary Education*, p. 24.

[8]M. Cournot, De l'Instruction Publique.

[9]Paulsen, on the stated purpose of the Gymnasia.
Russell, *Higher German Schools*, p. 74.

PART I

EVIDENCE FROM ANALYTIC PSYCHOLOGY

Analysis of the Doctrine of Formal Discipline. One of the reasons for the differences among people about the truth of the doctrine of formal discipline is the different meanings assigned to the phrase and to the other phrases used for the meaning. The Germans call it formal "Bildung," or formal education; it is also called formal training. While the second word in each case has a slightly different implication, they are at one in the emphasis of the formal element as opposed to the content feature. The following are some of the meanings which it has in actual use: First, it refers to the increase in general capacity of the whole mind when exercised in a definite way. The mind is supposed to possess as a unity mental energy, force, power, spiritual unity; it is a whole and homogeneous substance, without parts or phases. It may be compared to a tank of a simple gas: invisible, simple, active, possessing a unity of direct contact, as well as of function. A man who inadvertently uses the word "faculties" will hasten to say that he believes in a mental oneness. Under this position, a man trains his mind, and that is all there is to it. One person may do it in one way, and another in a different way, but the goal is the same: mental energy or sharpness results. Volkmann's statement that "whatever remains isolated, doesn't enter into development," is both true and false—true in that no such separate thing could be a real mental addition, but false in that there could be no such isolated knowledge. And strangely enough this thesis of spiritual power has come largely as a reaction against the faculty psychology, ignoring the truth of the Wolffian position in its efforts to show its falsities. But they have largely the same outcome for education: they both make a large opening for the generalized effects of special training. This point on its psychological side will be taken up later.

However, there is much naive observation to lead to this "central energy" doctrine. We see that a brisk walk, though its particular form may be limited to the exercise of a few muscles, has a general bodily effect of making one feel better; or on the other hand a day's work with a very limited lot of muscles, the others being in a state of apparent rest, makes the whole body and mind tired. Each action seems to get a general response, there seems to be such a thing as inter-organic sympathy. It is easy to carry over this generalization to the realm of mind, and to make similar conclusions for it. Conscious experience, also, supports this view, or seems to. We have a feeling of unity, a persistence of self oneness, not only longitudinally but latitudinally, not only from day to day, but in all the processes of the day at one time. We do not feel any such mental members, as we do physical. So whether we take analogy or direct consciousness, we may very rationally come out at the same place; namely, that no effect is local, nor even localized with branches into other regions. Mind is then a totality, a unity, and any effect on it is total, and must be.

The second meaning of formal discipline does not go so far. Man is a unity, but only in certain respects. It is now a matter of the one including the many. Man includes within himself many little men, each with a different character, yet in some mysterious way capable of assisting each other. These are called Perception, Memory, Imagination, Reason, Feeling, and Will. They are entirely disparate in character and in function, but each is as real an entity and also as homogenous in constitution as was "The Mind" of the first position. The precise attitude of this faculty psychology was laid bare in the phrenology of Gall who located each of these separate persons with the names given above, in a separate compartment of the brain. A man didn't reason; his Reason did. A man didn't memorize; his Memory did. A man didn't will, but his Will did. A man was not imagination, memory, etc.; but he had imagination, memory, etc., assistants which he employed when he needed them. He himself was different from all these, as they were different each from the other. He really was a something outside of his own mental states of Memory, Imagination, Will.

There are three important sub-phases of this general position, which need to be stated. The first was put forward forcibly by Beneke, one of the first strong opponents of the Wolffian psychology and its consequent pedagogy. He considered that there were three original possessions, different in degree but belonging to every person: (a) animation or sprightliness (Lebendigkeit), which shows itself in making of concepts, judgments, relations; (b) power or force (Kraftigkeit), which shows itself in greater moderation, less pain, fear, quicker recoveries; and finally, (c) impressionability, sensitivity (Empfindlichkeit); these three are fundamental impulses, original capacities, which become differentiated into many forms of activity in later life. Any enrichment, dwarfing, or modification of these primitive mental sources modifies all the mature processes depending on them. The analogy in the biological world is the differentiation in evolution from a single homogenous protoplasmic cell into the later complex animals. These original possessions constitute a sort of general intelligence, whose early cultivation or limitation diffuses itself into all later developments.[1]

The second is that represented by Dr. Bahrwald,[2] who conceives of the mind after the form of society, in which there are individuals, but which is much more than the mere numerical unity of these. There is a general intelligence resulting from the refinements and organization of experience on the passive side, and also in turn reacting upon and directing these on later individual experiences. This is also really the position taken by Spearman, who holds that there is a kind of dominating or directing mentality susceptible of training through the exercise of its specific expressions. "There exists a something that we may provisionally term General Sense Discrimination, and similarly a General Intelligence, and farther that the functional correspondence between these two is not appreciably less than absolute."[3]

The third sub-phase concerns the internal groupings of the faculties, within which cross effects are possible. With Socra-

[1]Beneke, *Erziehungs und Unterrichtslehre.*

[2]Bahrwald, *Theorie der Begabung*, p. 12.

[3]Spearman, *American Journal of Psychology*, Vol. 15, p. 272.

tes, knowledge determined will, and since then there have been claimants for interactionary effects in all degrees: *e. g.*, knowledge affects the feelings, and the latter the will; memory acts on reasoning, and reasoning on presentation, but not on the different faculties of the feelings; so also the love for beauty in form increases the sensitivity to the aesthetic in other directions, but is inoperative on the will.

The third view of formal discipline does not go so far as the second. While the distinction is a very real one, especially in practice, it is not easy for me to give it. Its cleavage does not run between separate mental powers which may operate in a relatively independent way, but, without distinguishing between the mind and body as such, between organic processes. The conception is that the whole person, as such, functions in a certain way this moment and in another way the next, and that we may rightly classify these acts on the basis of certain elements common to the processes rather than on the things or powers which make up, or are involved in these acts. Under the former scheme, one trained his attention; under this, he trains himself to do a complicated act called, as in the other, "attention." Or, one is trained in discrimination, which in its very wording puts emphasis on the act. This view refers to a congeries of nerve, muscle, attention, etc., which makes discrimination a function rather than a fact with mere content.

To illustrate, a wood-chopper in the handling of the axe uses hands, arms, eyes, will, etc. So likewise does he use the same arms, eyes, will, etc., in pushing the plane, or driving a nail. The same engine may push or pull, or carry a load; may run up hill or down, backward or forward. The classification is made on the act in which the engineer—engine organism, enters as the agent.

It conceives of every act as involving to a greater or less degree all the mental and physical capacities. For example, in reading in *Quo Vadis* of the fire in Rome, there is involved not only my ability to image absent objects, but also my capacity to memorize, to discriminate, to compare, to sense, to judge, etc., besides the motor accompaniments, which are equally present, though not to the same apparent degree. This posi-

tion is clearly in the mind of the manual training advocates who speak of the hand-eye-mind training, or the motor-sense adjustments and co-ordinations.

There is another phase of this diffusion theory of participation which I shall have to put in as a corollary, and yet it may have all of the truth there is in the doctrine of formal discipline. Emerson calls attention to the fact that character is not intellect, great mentality, or exceptional emotional qualities, or unusual volitional capacities, if we are to judge by the number or novel quality of their actions. Yet we say that certain persons have strong characters, commendable dispositions, a somewhat which underlies all those more noticeable mental and physical phenomena. Points in this general make-up may be separated out, such as caution, reliability, sanity, prudence, taste, atmosphere, integrity, wholesomeness, application, sympathy, etc. These are not acts; they are total habitual ways of personal response. Their unity undoubtedly connotes what we mean by "culture." These large personal values may not come from any transfer of special training in any of the senses already enumerated. Yet it may be that system, industry, economy in its largest meaning, personal unity, etc., may be obtained from the study of almost any subject, and, for the moment overlooking the knowledge side, from one subject as well as another. These accomplishments may be called generalized habits or modes of action. They are often referred to as the "sub-conscious" effects of education as distinguished from the conscious ones, such as improvement in "method," skill, or what not. They are largely unmeasurable and untestable, but constitute the "color," the "atmosphere," the spirit, the character. We have become a part of every person and thing we have touched.

The last view of formal discipline, to be now described, is the extreme of the first. It holds that we are machines for doing things, just as truly machines as any that our hands fashion for sawing lumber or rolling iron. We are a system of levers, pulleys, etc., a conscious machine, and the mind is a word used to distinguish a certain phase of the machine; for example, it defines the purpose, sees the end, marks out the way—it is the cabman on the carriage. Our learning to do this and that no

more signifies that we can do something else than the fact that a saw is tempered and sharpened for sawing signifies that it can make a shovel. It may make a shovel, but that is not because if its edge being a good saw but because it is of such form that it may be adapted to the two purposes. So we may do one thing well and also do another well, because we are so pliably constructed that we may do these two things well. Also, I may be able to do one thing well and another very poorly, because in this case I am made correctly to do the one and incorrectly to do the other. To do the other, I shall have to make some new combinations of muscles and nerves, etc., that is, make a new machine for this new work. In support of this are brought forth many men of great skill in one line unskilled in others, who have to get this second skill if they wish it, by as arduous labor as if they could do nothing else. There is little or no cross influence. We do not cultivate "powers," or the "mind," or "faculties," or an "organism," but are drilled into specific modes of action, each with its own peculiar coordinations, mental and motor. Of course, the practical advice of this doctrine in school life is to get at a thing that is to be done, without any intervention or doing of another thing as a medium.

We have no Memory, Imagination, Reason, but can memorize this series of facts, not necessarily that; have good judgment about this situation, but not another one; can easily picture certain conditions, but not others. As with machines generally so with men: there are many sorts.

These four positions seem to me to define the territory in which the problems of formal discipline arise. There yet remain the two questions: What is it that is carried over? and What are the means?

The first answer is that studies give an increase in the native force, original power, brute capacity—the foot-pounds of energy so to speak. "Intellectual capacities" carry here the idea of room that has been enlarged; spiritual or emotional range that has been extended. It is as if more potentiality had been added. No one faculty is sharpened, no special skill or knowledge secured; but just as food in the body is carried to

all parts of the organism of the growing child by the circulatory system, without in any manifest way giving skill or deftness to any one part, so mental pabulum, through some sort of mental circulation, apperception, or something else, adds energy, force, power, strength, range, capacity, richness to the soul. The mind is built up by what it feeds upon; not simply by what is taken into it, but by what is assimilated. Then the teacher's problem becomes: "What are the studies with these largely nutritious elements in them, and what are the proper ways of presenting them so that they will most effectively be ingested by the mind, and, as properly digested food, eventuate in action? What such a teacher is after, then, is not this or that particular skill, or this or that body of knowledge as such, but the issuing of opinions, judgment, poise, cosmic and human sympathy, insight and adaptability—in short, the quantity and quality of the larger life.

The second position, of course, denies the first, and holds that the only result which is more than local in its effect is knowledge,—knowledge of facts which are of more or less general application, and of methods particularly.

It is held more narrowly that one gets the idea of accuracy, say in mathematics, as a proper rule to follow in solving any sort of problem; and so though one is never to use mathematics yet as it necessitates *par excellence* the use of care, precision, etc., it is the subject to study so as to secure these methods which are of such universal application. The function of schools is to bring out in the clear forefront of consciousness from the fragments and ends of things called for convenience algebra, geography, etc., the common essences, their common values, and generalize them. Get the knowledge first and then the habit of seeing and experiencing in a vital way such things as truth, honesty, adaptability, humanity. Dr. Moore, in his article [1] on this subject, points out that the Greek teachers so universalized mathematics in their teaching, that number and geometrical form became to them a real way, a vital category for thinking any and all sorts of things universal, and had been made to arise out of the particular, in no mere metaphysical way, but in such

[1] *Western Journal of Education*, May, 1903.

direct contact with life that ever afterward it became an apperceptive form of the mind. We surely do have concepts not limited to the particular act which gave them origin.

The third position holds that skill, keenness, facility is transferred. Logic makes an acute man; mathematics, an exact man; history gives, not the method of memorizing, but increased readiness; Latin trains to close observation; astronomy, to finer and sharper imaginative ability. The boy who is drilled in manual training does not get chiefly a method of procedure or way of going at things which he chiefly realizes would be good in the business world when he gets out into it; but he is made into an accurate, polished machine, who will plan his law cases as he did his joinings. The student will remember the cost price of his goods because he has learned his Greek and Latin vocabulary; he will use good judgment in putting in an orchard or an irrigating ditch, because capacity was exercised in literary interpretation. Prefaces to many of the text-books used in our schools freely confess that the knowledge which will be carried away will be of limited application, as they can very well say without fear of contradiction of algebra, most of arithmetic, much of geography, and still more of language work, especially analysis. They could hardly claim for much of this work any wholesale mental enrichment, or deepening of the sympathies or appreciations. Nor do pupils from it learn methods of any very large application, but they are drilled in discrimination, in analysis, in observation, etc., and these arts when once acquired are usable, of course, wherever they are needed. Calvin Thomas says, "the value of German lies in the scientific study of German itself, in the consequent training of the reason, of the powers of observation, comparison, and synthesis, in short in the upbuilding and strengthening of the scientific intellect."[1]

The last view to be mentioned is the one espoused by the ultra-radical opponents of any sort of formal discipline. There are no general powers, even relatively general; there are only specific capacities. We learn to do this thing and that; we are

[1]Quoted in Thorndike, *Educational Psychology*, p. 83.

very complex engines for accomplishing well defined ends, and though this machine may do many things, its one trick has nothing to do with the other. A broomstick may be used for a cane, but its original usefulness will in no way affect its second performance. Consciousness defines the end of the function; the coordination of joints, muscles, nerves, etc., constitute the means. We learn to do by doing. Yes, but definitely, we learn to do this thing by doing this thing. There is nothing incidental, indirect, or mediated in this scheme. If a child is to learn to read, put him at it. He can't do it by listening to the birds or looking at the flowers. O'Shea, for instance, declares that "particular experiences give adjustment to particular situations only, and not to all sorts of situations."[1] A good teacher may make a poor father; a good lawyer, a poor statesman; a good scientist, a poor citizen. Not long since a tin manfactuurer told me that a man presented himself at the shop for work, with a strong letter of commendation from his last employer. He was given materials which had been cut out by machinery, to put together. As I recall, they were to be coffee pots. He puttered about the work for a long while, and then reported to the manager that he could not do the task. But he said, "If you will let me have the sheet tin, I can do it." He was so permitted just to test his word; and with great skill he made a complete vessel in a few minutes. This example illustrates well the position which these anti-formalists take.

There is a corollary to this last view which may be more important than its principal claim. It is that one action will aid another to the extent that the two involve the same mental coordinations. For instance, since the muscles of the arm are employed in drawing as well as in writing, so the training in one process will be of some assistance in the other. Voice culture for purposes of singing might assist the public speaker or elocutionist. "The thesis which I shall try to defend," says Thorndike, "is that a change in any one function alters any other only in so far as the two functions have as factors identical elements. The change in the second function is in amount that due to the change in the elements common to it and the first.

[1] *Education as Adjustment*, p. 246.

The change is simply the necessary result upon the second function of the alteration of those factors which were elements of the first function and so were altered by its training. To take a concrete example, improvement in addition will alter one's ability in multiplication, because addition is absolutely identical with a part of multiplication and because certain other processes, *e. g.*, the eye movements and the inhibition of all save arithmetical impulses, are in part common to the two functions." [1] This conception, as opposed to the others, may be called the biological one, as it is the logical outcome of the doctrine of adaptation or evolution. Thus there is no actual transfer here at all of power, skill, or method. Such seeming influences are due to the external setting, and not to the real differences in organic functioning.

There is evidently another source of confusion among the writers on this subject which I have not mentioned. One will uphold his position by reference to the one-sidedness of a specialist, who has all the good qualities in his chosen line but is noticeably uneducated in other things. Indeed, he may have been at one time in his life fairly capable in several fields, but his skill in these was affected in inverse ratio to his skill and learning in the speciality. Another advocate will, from the same volume of human history, select cases where men have taken the restricted regimen of the old classical college, and have later stood at the head in some art or profession of which their college taught them nothing,—stood higher, in fact, than those who by the apprenticeship system had narrowed themselves to that one thing only. It is possible that training carried on for a short period has a diffused effect, which manifests itself in a more or less heightened tone of all other parts, hence all other acts; whereas, if the practice is of a very specific kind and kept up for a long period, the tracts of discharge become more pronounced, the other paths and complexes become increasingly isolated and less used. Growth and development have ceased and the individual has become a machine, a specialist. This has not only empirical support, but it harmonizes with the doctrine of infancy before referred to. Childhood,

[1] Thorndike, *Educational Psychology*, p. 80.

with its vacillating interests, its unsystematized movements, its many sided curiosity, the very apparent stimulation of all sorts of motor reactions by one attempt to do one thing, say to write, contrasted with the processes of the adult which are both exact and limited in their noticeable influence to a narrow field, suggests that there may be more of truth in the doctrine of formal discipline for one period of life than for another, and also for one length of time as opposed to another.

The Analysis of the "Common Element." I am going to start out with a thesis stated by Thorndike in writing on this same subject: *viz.*, "A change in one function alters any other only in so far as the two functions have as factors identical elements. The change in the second function is in amount that due to the change in the elements common to it, and to the first." (1) This conclusion, which has been arrived at by the examination of the evidence, both logical and experimental, is put at the beginning for the purpose of giving an arrangement of the evidence. But "common element," though used very extensively as a final concession by antiformalists, (2) is a very ambiguous term, and I shall now call attention to some of the ways in which it has been employed.

It is first to be noted that the situations to which the above thesis is applicable cannot be determined in an *a priori* fashion by analysis. It is very difficult, also, to know when there are common elements. For example, the advocate of manual training, on examining the act of a pupil in selecting a piece of wood to make a thin box, and the act of the same individual, now a man in life, in determining in what city it is best to locate his steel plant, says that "judgment" is the common element, and that the exercise in the former process carries over to the latter. This is a mere topical question, but it is not unusual in pedagogy to find such queries made the basis of educational theory and practice.

As this whole inquiry has to do with processes, we may rightly consider the chief factors to be, (a) the mind, (b) the

[1]Thorndike, *Educational Psychology*, p 80

[2]See article by members of the Scholia Club in the *Western Journal of Education*, 1903.

body, (c) the environment, and (d) the interaction of these as a unity. The common element, therefore, must be present in one of these four situations. First, it may be in the likeness of the product of acts, or of objects or environment. An external similarity, multiplying six by seven, or adding eight and nine, are alike in that numbers are numbers.

The act of a cat getting out of a box, and of a man are identical; both open a door by pressing a latch. A parrot talks and so does a person. The problem solved in the school arithmetic may be the same as the one in the counting house. A child of Mr. Smith is none the less his child when taught by him at school. But both empirical evidence and investigations declare such cases, though identical when viewed externally, to be very distantly related. The cat's act in getting out of the box is almost wholly a result of unconscious selection; the man's is a highly deliberative and conscious one. (1) Certain numbers as such are identical, yet the correlation between the simplest ways of handling them may be very small. (2) For given actions it has been sufficient to identify the elements in the curriculum of the elementary grades with the elements of the larger life, but it is only a superficial, not a psychological likeness. In the case of the tinner referred to a few pages ago, there was an identity of product only. He could make the vessel in one way only from the tin plate. When required to do it in a new way, the chain of associated acts to which he was accustomed was broken in the middle, and the initial ones completely dropped. He was as helpless as would be a child to take up the steps in a demonstration in geometry, many steps along. Yet he was dealing not merely with similar, but identical material and output, and, more minutely, in ways or processes which were in part perfectly alike.

Or, again, a fruit broker knows prunes as to their size, color, species, weight, preparation for market, etc., all in relation to market values. But put him in the orchardist's place who looks at the same fruit as a producer, and he is not so capa-

[1]Thorndike, *Animal Intelligence.*

[2]Aikens, Thorndike, and Hubbell. *Psy. Rev.*, IX, pp. 374–382.

ble as an ignorant laborer. Yet both are dealing with the same object. Consequently no analysis of the external conditions, or subject matter, will suffice to discover the elements which, because of their sameness, can aid each other.

Nor does "common element" refer to similarity of two mental states, though they may both have the same name. Thorndike and Woodworth ([1]) have shown that in the cases of judging the areas of slightly different forms, where most of the mental elements are apparently closely alike, as attention, visual sensation, comparison, etc., the diffusion effects were very slight. The taster of wines is not noticeably more sensitive to differences in qualities of tea than ordinary folks.

Again, it is not easy to know what are identical elements when the body as a machine is analyzed. It is easy enough to say that certain muscles and nerves are employed in two acts, and that training them to do one thing well will of course train them to do another well; but such conclusions seem only partially warranted in practice. Dr. Jastrow([2]) in extended tests on two sleight-of-hand performers, found that in ten out of twelve experiments, involving dexterous movements of hands and eyes —the very points of their skill—they were no better than the average student, and in some cases worse than the average. On the track team, the sprinter is no great walker. The artist is not famous for his penmanship. It is quite probable that these visible members of the body are mere appendices to the really basal participants in any movement; namely, the cells and fibers of the nervous system. However, this is yet too great a *terra incognita* to find in it any common elements.

There yet remains the total organism environment in which to seek the "common element." It would be difficult to get at the bicycle's secret by standing it up and looking at it. The historical philosopher would probably try it in that way; but the machinist would put the wheel in *motion,* and taking in the entirety, bicycle, speed, path, etc., get his principle. The

[1] *Psychological Review,* Vol. VIII, p. 344.

[2] Jastrow, *Science,* N. S., May 8, 1896.

environment is often set over against the subject for purposes of practical distinctions, but for scientific purposes, connected with functions, any such breaking asunder must destroy the very thing sought for. The real basis of action is not the sensory motor tract alone. The rather is it an action, circle, a totality, where the so-called environment is a vital, living part,—in it are involved all causes: final, efficient, and formal. Many cross sections of this circle may finally give the analyst his essential common element, and when found, it may be the least suspected phase of the whole process. For example, Woodworth ([1]) found that mere exercise of the left hand, in the effort to reach an accomplishment, did not give an increase in excellence in the right hand; it must be *successful* practice. And so, for the present, the only final method for reaching the truth desired, *viz.*, what acts aid other acts, is the one of experiment, of trial.

I return now to the general thesis which is to be defended: that there may be, or may not be, a transfer, and that it may be of different character in different cases, and of varying degrees.

There are several supports for this judgment, though not proofs, found in the field of biology. We are walking histories of the past; every tooth, nail, lineament, member, tells the skilled observer what we have been doing, under what conditions we have lived. We have developed under the stress of circumstances, which have always been specific situations. As the needs of life changed, new appliances were developed to meet them, and as the latter strengthened, the old appliances, their need gone, slowly passed away, or remained as vestigial organs. So we do not see any and all sorts of things, are not attentive to any and all sorts of objects, nor able to imagine any and all sorts of situations; but we see, imagine, and are attentive to only those objects which have been a vital part of our environment.

From this statement it is inferable clearly that any such unitary basis as an amount of supposedly homogenous energy, or a complete organic function, ([2]) in every act is untenable.

[1]Woodworth, *Psychological Review.* Mon. Sup. 13.

[2]See pp. 14, 19.

So specific and needful are some performances that others, instead of being augmented thereby, are the rather slighted and dwindle away. On the other hand, this very capacity of the animal to adapt himself to new situations, implies such a relation between new possible acts and the old ones, that the latter will aid the former by participating, wholly or partially, in them.

This point is brought out by examining the animal kingdom genetically. Cats and dogs are wonderfully skillful in doing certain things, but they learn other closely similar acts with great difficulty. It is near the truth to say there is, with them, no transfer from one act to another. With monkeys, there is greater pliability of the organism, and with man, still greater. He, however, is simply a more complex machine, with all his powers and abilities specific and not general. So his old habits do aid in acquiring new ones of a certain kind; *viz.*, those which are largely alike in some biological essence to the old.

From the study of the growth of the child, the same point is deducible. From youth on, life is selection,—taking on this habit or that mannerism, and finally this trade or profession, and finding, as in the case of Darwin, the neglected possibilities becoming more and more impossible. The boy can easily learn to ride the bicycle, or to speak a foreign tongue, but the adult, whether educated "all round" or in a specialty, finds much obstruction.

The child can readily learn several languages, and speak them all equally well, but necessity forces a choice, which becomes a habit—and that gate of opportunity is closed, but closed that others may be opened. The man has simply become a machine to grind out a certain grist: educational, legal, medicinal, or what not. Habits, or training in certain ways, then, aid others by cooperating with them; by assisting them.

But there is the other side. He is never a pure machine; he is alive, and is changing, so that literally no two successive moments find him at the same place. He represents an unstable equilibrium, hence every successive act is not what the preceding one was. Yet the preceding acts are the strongest

determinant of what their successors shall be,—that is, education is possible. The effects of one day are not final, but determine a new and different condition of tomorrow. "As men never think the same thought over again, so they never perform the same act over again, and the essential difference between living and non-living things lies in the fact that living things are constantly changing, and not merely changing under the influence of external surroundings, but that any change that takes place in them is not lost but retained, and, as it were, built into the organism to serve as the foundation for future actions."(1)

It surely would hardly be held that the knowledge obtained in school can be used again only under the conditions in which it was first taught. As Bacon taught, it may become power in realms much removed from its original source. It becomes a means of guidance in undreamed-of situations. Newton learned, no doubt, his numbers in connection with balls, stones, people; he applied them to stars and unseen forces. Knowledge is never *mere* cumulation, a matter of numerical increase, as the atomist would logically hold; as surely as the mind lives the individual facts are jostled along until they are either forgotten, or enter into vital connection with few or many other mental states. If the extended application does not arise, it is probably due to the character of the knowledge rather than to the nature of the mind.

This last thesis is supported by Moore, who considers the transfer of training to come through an acquaintance with methods, ways of handling one's self, data, principles, tools.(2) It is also strongly emphasized in the educational philosophy of Dr. Dewey.(3) The school is to be a *method of approach* to the larger life, a place where the social forms and processes are acquired. So the tests, in such cases, of effective education, would be of the children's familiarity with social procedure, and their ability to use this knowledge under novel circumstances.

The function and character of consciousness, the teleology

[1]Moore, *Western Journal of Education*, May, 1903, p. 299.

[2]Moore, *Western Journal of Education*, May, 1903, p. 307.

[3]Dewey, *School and Society*.

of knowledge, throws a side light on the problem of transfer. So long as mind was made a receptacle for whatever might creep in through the "windows of the soul," as Dr. Harris calls the senses, little could be said one way or the other on formal discipline, unless there went with it the notion of mind as a sort of spiritual entity of the homogenous fluid sort. In that case, transfer would be large and inevitable. But mind in fact is selective, active, motor, not as a wound-up toy which runs helter-skelter, nor as a vessel which takes in everything, but as a train on a track that is going somewhere in a special way. So it goes well in this direction and poorly in another. We have eyes to see, but we do not see many things which are before us. We discriminate easily here but not there. These facts are remembered at a glance; others will hardly stay after many repetitions. These are the evident truths of consciousness, aside from the question of whether one act aids another. And it is the same in the emotional consciousness. A physician by whom I sat at the opera lately was transported by the music; he could literally feel a bodily reponse throughout. Yet afterward he said he could not conceive of what religion meant or how it felt, or of what nature its emotions were. The same distinctions are applicable to the will. We desire and are strong here; we are colorless and ineffective there. We know of visuels, tactiles, audiles; of people who can see words, but can not say them; who can say them, but cannot write them; who can hear them, but get no meaning from them, whereas if they see them they can understand them, etc. So the "all-round man" and the "many-sided interest" are figures of speech. From the appearance of the impulses in the child, with its accompanying movements, to the philosophic or professional interests of the adult, the interests, the motives, the methods, the feelings, the ideals, the processes are functions,—are purposeful.

PART II

EVIDENCE FROM EXPERIMENTAL PSYCHOLOGY

Empirical Studies of Formal Discipline

The following section is a summary of the direct experimental data in so far as they have not already been summarized in the chapter on Formal Discipline in Thorndike's *Educational Psychology*:

Dr. Jastrow reports a series of laboratory tests made on two men famous for their skill as sleight-of-hand performers,([1]) and at the same time compares the data with that obtained from a group of students who were subject to the same tests. The skill of these men, due to years of practice, was such as to put them in the rank with the world's few thousands of best "hand-and-eye" trained people.

He first determined their tactile sensibility—distance for two points—with aesthesiometer. Mr. Hermann, 3.5 mm.; Mr. Kellar, 2.5 mm. Average results from a considerable number of miscellaneous individuals, 2 mm. The next test was to arrange five weights in a series, in which each one weighed 1-15 of previous weight; Mr. Hermann failed, Mr. Kellar succeeded; both failed for weights differing by 1-30. In general test, 92 % got the first test all right, 66% the latter.

Sensitiveness to texture: Subjects passed their fingers over sets of wires wound closely. In the first set, the wires in each successive case were one-fourth coarser; in the second set, one-eighth coarser. The sets were to be put in order. Mr. Kellar put first set in correct order, but got all wrong in the second set. Mr. Hermann got both wrong.

"Another form of motor and tactile capacity was tested by requiring subject to arrange in order a series of bars of varying

[1]Jastrow, *Science*, May 8, 1896.

length by passing the forefinger across them." Both Mr. Hermann and Mr. Kellar did this successfully, sixty per cent of a miscellaneous crowd also did it correctly. Both Mr. Hermann and Mr. Kellar are ambidextrous. They were tested in moving both hands equidistant from a central point to right and left. Average distance for right hand was 241.5 mm., for left hand, 247 mm. There was no regularity as to which hand would go farther from central point, as is shown by the following figures: for Mr. Hermann, 318, 330, 123, 302, 116, 260 for right hand; 316, 344, 140, 268, 160, 225, for left hand. This variation in the distance of the two hands is common to people in general. For Mr. Kellar, for right hand: 281, 357, 404, 155, 108, 313 mm.; for left hand, 268, 333, 411, 187, 133, 337. Average excess for left hand, 8.5 mm.; average for right hand, 270 mm.; left hand 278 mm. There was no regularity as to which moved the farther.

"The subjects were required to mark off on the three arms of a cross a distance equal to that marked off on the upper arm of the cross, 50 mm. The lengths of the arms were unequal. Results for Mr. Hermann, on the left arm, 70.5 mm.; right arm, 44. mm.; lower arm, 60.5 mm. Mr. Kellar, left arm, 54.5 mm.; right arm, 52.5 mm.; lower arm, 50 mm. Average for a miscellaneous group: left arm, 54 mm.; right arm, 54 mm.; lower arm, 61 mm. Mr. Kellar's average for the lower arm was less than the general average.

Visual perception test: "form alphabet;" "twenty-five characters were made, composed of short and long, vertical and horizontal strokes in various combinations. Two hundred and fifteen of these were printed in miscellaneous order upon a sheet. A certain one of these was singled out for identification, and the subject was required to indicate as many occurrences of this character as he could detect within a limited time (90 seconds). Mr. Hermann marked off eight correct ones. Mr. Kellar marked off eleven. The general average of persons succeed in recognizing about eight forms in this time."

Tests for quickness of movement and of mental processes: "For Mr. Hermann the maximum number of movements of the forefinger alone was 72 in 10 seconds, or 7.2 per second; and of

the forearm, 75, or 7.5 per second. For Mr. Kellar, forefinger, 83 in 15 seconds, or 5.5 per second; and for the forearm, 127 or 8.5 per second. The average for large number of individuals for the forefinger movement, was 5.4 per second; and of a group of ten persons, 4.8 per second. The average forearm movement of the same ten persons was 7.5 per second. It thus appears that the movements of both Mr. Hermann and Mr. Kellar are rapid."

Reaction time of Mr. Hermann to touch on right hand, 104°; variation, 11°; Mr. Kellar's time was 129°; average variation 10°. For sound for Mr. Hermann, 163°; average variation 32°. For Mr. Kellar, 116°; average variation, 25°. For visual reaction for Mr. Hermann, 126°; average variation, 26°; for Mr. Kellar, 125°, average variation, 6°. For a group of miscellaneous people: touch, 172°; sound, 165°; light, 176°. "It thus appears that both of the special subjects tested, their reaction time was quicker than that of the average individual."(1)

To test manual quickness of movement: Time was taken between the touching of two instruments three feet apart, with same hand. Mr. Hermann's time, 610°, variation, 76°; Mr. Kellar's, 299°, variation, 23°. Compared with ten other individuals, whose average was 364°, Mr. Kellar's time is below normal, although it is equaled by six out of the ten; and Mr. Hermann's time is very long.

Distribution of red and blue, associated with movements of right and left hands. "Mr. Hermann's time was 301°, average variation, 64°; Mr. Kellar's, 256°, average variation, 56°." Both shorter than with the miscellaneous group. But a more complicated reaction involved a movement with any one of the five fingers in response to the appearance of the numbers 1, 2, 3, 4, 5, behind an opening in a screen." Mr. Hermann's time for such a reaction was 901°, with a variation of 200°; Mr. Kellar's time being 753°, with a variation of 91°. The average time for ten individuals for such a reaction is 588°, with a variation of 84°. So "their time is below normal in a reaction involving a simple distinction and choice, and is con-

[1] Jastrow, *Science*, May 8, 1896.

siderably larger than the normal in a reaction involving a complex distinction and choice."

For quickness in perception of color: Mr. Hermann, compared with 40 persons, had about the same quickness 5 to 4.5, had much better when color and form were combined: 3 to 1.8; and also for words seen separately, 2 to 1.4, but could read clearly fewer words in one exposure. So Jastrow concludes, "On the whole as regards the quickness and scope of perception, Mr. Hermann would rank well (except in reading words in a sentence), but by no means exceptionally well in the general average." Mr. Kellar, in a similar test, ranks below Mr. Hermann in all but the reading of words in a sentence, but would be equalled by 86% of college students."

"I have repeated these tests on a local sleight-of-hand performer, and find for him a good record and particularly a great quickness in movement."

At the Montana State Normal College, Dr. Bagley undertook to determine whether the habit of producing neat, well arranged papers in the arithmetic work would function in the written work in English, Geography, and other studies. The experiments were carried on for three months in the intermediate grades. The results are most startling. The improvement in the arithmetic papers was large and very noticeable from the first, but during the same time there was not the slightest noticeable improvement in the appearance of the language and spelling papers. [1]

A recent extended contribution [2] to the problem of formal discipline is limited strictly to the territory of memory. There were eight subjects, all adults and people of large training. The tests were secured through use of A. non-sense material: (1) letters; (2) figures; (3) non-sense syllables. B. sense material: (1) words; (2) Italian words with no logical connection; (3) poetic phrases, and (4) prose sentences. By these the immediate retentiveness was determined. For testing the rate

[1] *School and Home Education*, 1904, p. 102.

[2] E. Ebert and E. Meumann, *Archiv fur die Gesamte Psychologie*, IV B. IV 2 H, 1904.

of forgetting, another test was set consisting of long rows of non-sense syllables, rows of many-formed figures (visuella Zeichen), Italian vocables, poetic phrases, and prose sentences. It is to be noted that these preliminary tests were very extended, especially the second ones, which were relearned at intervals of increasing length, the rate of forgetting being thus determined by the comparative number of repetitions necessary to regain them.

Then came the practice series, consisting of 32 rows of non-sense syllables, 12 in a row. However, only 8 rows were learned, and relearned once, when a test series was again given. This method of retesting with the long preliminary series was thus gone through three times, and seemingly occupied much more time than the practice series. This taken in connection with identity in kind of some of the material, and great similiarity of the rest, made it possible to report the following improvement in per cents:

	Non-sense syllables.	Figures.	Words.	Prose.
B.	60%	85%	11%	
Br.	40%	57%	28%	
F.	125%	160%	60%	
M.	16%	22%	11%	9%
S.	33%(1)	57%	28%	
W.		14%(2)		66%

These appear sufficient to the authors to enable them to say: "It may not be denied when the facts are taken into consideration that there is a general memory training, also that it is out of the question to increase through practice any special memory isolated from the totality of memory function."(3)

In order to test James' position on the incapability for increase in the memory powers, Winch exposed to different school grades, at intervals of about 7 days, twelve consonants arranged in four rows. After being presented, they were reproduced in writing in 25 seconds by the children. As an example of the increase, standard seven may be taken. Tests with

[1]p. 165. [2]p. 157. [3]192. (Amounts less than 1 per cent omitted.)

entirely different combinations of the consonants were given on June 5, June 12, and July 3, and the results of increase in memory are shown by the following per cents of consonants remembered in proper order: 25.5, 30.3, 32.7. His conclusion is that James is wrong; that "pure memory" is markedly improved by practice. When one considers the shortness of the practice and the largeness of the results, it seems pretty evident that the interpretation of their efficiency was familiarity with novel data, and not increased native power.

Mrs. Carrie Liddle practiced sorting a pack of well-shuffled cards of six different colors, as rapidly as possible. All the cards as they were taken from the pack were put in a particular stall. When the maximum speed in sorting this pack was attained, another pack made up of cards differing in color from those in the first pack were sorted. The sorting of this second pack was kept up until a speed limit was reached. Then a pack having various geometrical designs on the cards was distributed in stalls as were those with colors. She found that going over from one pack of cards, after a speed had been reached, did not raise the time of curve much, if at all, and consequently that ability secured in discriminating one set of colors, or designs, aided in doing the same process with other colors and designs. And this was invariable for the eleven subjects, some of whom were children; the others, adults.

Psycho-physically the process was very complicated, so that while there is no question of the fact of distribution of cards of one sort, with greater facility, from practice with another sort—and that is a pertinent conclusion,—yet it is possible that this facility was due to the persistence or presence of, and hence training of, some simple motor co-ordinations.[1]

Cross-Education. Another series of studies bearing on the general topic are the "cross-education" experiments. By this term is meant the results in skill, power or size in one side of the body produced by training the other. When Blair electrically stimulated the muscles of one ear, the motor discharge was simultaneous in the other, there being a tendency for the

[1]From an unpublished thesis on *Transfer of Mental Facility*, University of California, 1904.

two to work together, as with children there is a tendency for both parts of the body to work together. So there is this much of a cross effect: a co-ordinate stimulation. However, "when an impulse has once actually reached the muscles, the process from that point onward is one of segregation, elimination, co-ordination, adaptation."

Bryan, at the conclusion of his work on motor-ability says: "It is certain that the right hand does not outgrow the left, and the fact that at 15 and 16 years of age, the probability of $R > L$ is less than at 12, 9, or 6 years of age, seems to indicate that the left has gained upon the right. At all events, the fact that the left hand should make such relative improvement both in ability to carry out a movement, in which the right hand has had all the practice, tends to confirm the probability of bilateral effects of practice," which he says is largely mental.

"The amount of force which can be exerted through one hand, and the time during which it can be exerted depend upon whether at the same time or just preceding, force has been exerted through the other hand." ([1])

Volkmann, by practice, increased the sensitiveness to the difference between two points on the left arm from 23.6 to 11.2; at the same time there was an increase in the right arm, which was not practiced, from 26.4 to 15.7.([2]) To determine whether other symmetrical parts are thus trained, he found the distance within which two points appeared as one for the tips of the fingers of both hands, and also for the left arm. Increasing by practice the distance on one of the fingers of the left hand, increased it for all the other fingers but not for the arm.

The most extended experiments on this phase of the subject come from the Yale Psychological Laboratory. The first are from W. W. Davis. ([3])

Oscar Raif, Professor of Music in the Berlin Hoch Schule, took the average speed of some pupils for both hands. For the

[1]Bryan, *American Journal of Psychology*, Vol. V, p. 202.

[2]Thorndike, *Educational Psychology*, p. 86.

[3]*Yale Psychological Studies*, Vol. VI, p. 7.

right, it was 116 per minute; for the left, 112. He gave them exercises for the right hand only to develop rapidity. After two months the right hand yielded 176. Then he tried the unpracticed left hand, and it had gone up to 152, from 112.

(1) Exercising the great toe in rapid tapping, brought up the ability of the other foot, and both hands, though to a much less degree.

In lifting weights by the right arm, its strength and size were increased; and at the same time and on the same parts in the other arm, which was unpracticed, there was an increase.

Also in lunging with a foil, six subjects were practiced, with right hand, with the effect of increasing its accuracy very markedly; and also, in a lesser degree, the accuracy of the left hand, which was not practiced.

The records of four experienced fencers are given. Accustomed as they are to use foil in right hand, they were little more skillful with the left hand than the unpracticed. The author remarks that the "form" of the right and left sides was very alike, and that the "fencers themselves were surprised to find it so easy to lunge lefthanded."

(2) Group IV practiced the right hand in grasping a stick, but the transfer was of a negative sort, there being losses. This may be due, says Davis, to the fact that "the muscles learned how to contract properly for pressure of the cylindrical stick, but gained no advantage from this for gripping the dynanometer."

"F. was a strong, healthy man, a trained and skilled gymnast. During 2 1-2 weeks practice—in tapping with right foot—he was not able to make any marked gain. He himself said, 'If I try to hurry too much, my foot stops almost altogether.' His gymnastic work had so developed his ability to send down to large muscles immense amounts of stimuli for action, that for a test involving small muscles he could not become an expert." (3)

[1]W. W. Davis, *Yale Studies in Psychology*, Vol. VI.

[2]W. W. Davis, *Yale Studies in Psychology*, Vol. VIII, p. 75.

[3]Davis, *Yale Studies in Psychology*, Vol. VIII, p. 81.

Of two subjects, one with much previous training, the other the reverse, the former gained in skill with a new instrument much more rapidly, as the table shows.[1]

	1st final	2nd final	Average
Previously trained	10.48%	14.36%	12.42%
Not previously trained	−1.27%	2.50%	.61%

On classifying subjects beforehand as phlegmatic and nervous, Davis found that a certain form of exercise had more effect on one class than another. Observe the following table:[2]

The effects of this sort of practice on one person are indicated here:

	1st final	2nd final	Average
First, light practice	2.78	.24	1.51
Second, vigorous practice	12.04	6.85	9.42

The following table indicates two things: first, the transfer from the practiced to the unpracticed hand; and, second, the difference in the amount of transfer as produced by vigorous and light practice. The ergograph was used to secure the practice.

	Distance weight was lifted in beginning.	Distance after 3 wks. of practice (hard).	Gain.	Distance after 7 wks. further light practice.	Gain over 1st final
Left hand	1341	1488	11%	1757	18%
Right hand (not practiced)	1316	1492	13%	1541	3%

Note that though right hand gained much in first effort, it did not at second. "This fact proves that the unused does not always get a share in the benefits of exercise. One side, by long continued practice, may become *over-developed*, while the strength of the symmetrical muscles on the other side may even be diminished."[3]

Joteyko fatigued right hand by exercise with ergograph, and finally secured pressure records with dynamometer for both

[1]Davis, *Yale Studies in Psychology*, Vol. VIII, p. 92.

[2]Davis, *Yale Studies in Psychology*, Vol. VIII, p. 93.

[3]Davis, *Yale Studies in Psychology*, VIII, p. 100.

hands, as was also done at first. There was a *decrease* in activity of left hand about equal to 20%. He concludes "the decrease in the unused hand was caused by the loss of energy in the cerebral enters."([1])

Davis with the dynamometer tested both hands, then practiced one of them. About half of the fifty subjects trained one hand, and the remainder trained the other. There was a gain of 8.06% for the men with the trained hand, and an average gain of 9.92% for the untrained. For the women, there was a direct gain of transference of 5.84%. There was a transfer effect for all the men but one; for the women, six failed to gain at all, and five lost somewhat."([2])

([3])The left biceps and right abductor indices of two subjects, R. and W., were trained. The gain for W. was 26%; for R., 43%. But also the left abductor which was not exercised showed a gain of 100% for W., and 40% for R. The gain in the right biceps, "the most remote anatomically," was correspondingly less—8% for W. and 32% for R. Other experiments were made by training the right abductor indices, with an effect of 52% gain for W. and 45% for R.; and left biceps, of 2% for W., and 4% for R. So that "it appears that the accessory muscles of one side gain approximately as much from the exercise of the corresponding muscles of the opposite side as from the exercise of the fundamental muscles of the same side. That is to say, the diffused motor discharge from one side to the other is as great as that from the shoulder center to the finger center." For example, "the left abductor had no training, and shows a total gain throughout the entire series of about 300%." "Also it seems certain that the exercise of any muscle reacts upon all related muscles, which is to say that diffusion takes place in both inward and outward directions."

The right hand and left were both tested for keeping up three balls. Then the training for the right was continued until great skill was reached, when the left was tried again. No tables

[1]Davis, *Yale Studies in Psychology*, VIII, p. 104.

[2]Davis, *Yale Studies in Psychology*, VIII, p. 72.

[3]Wissler and Richardson, *Psychological Review*, VII, p. 29.

are given, only the curves, which show: (1) "That the record for the left hand was in all cases higher than the preliminary test, never in one case dropping to it." (2) "All the subjects made a better record with their untrained left hand, when practice was finally begun, than they had been able to do with the right hand at the beginning."[1]

"Volkmann found that six months of regular practice in distinguishing small visual distances, in which his eye gained remarkable power, had no effect whatever on his ability to distinguish small tactual differences."[2]

A Miss B. was required to insert a pointed iron in a series of holes of diminishing size. She did it first with the left hand, giving 50% of successful trials. Then training with the right hand so that the number of successful trials rose from 60 to 88, the left hand was again given its turn, showing 76% of successful trials.[3]

That the chief element here is the attention is shown by the lowering percentage if there were any distractions, and (second) if the attention was focused on the movement rather than on the hole. "The training was psychical rather than physical."

By using a dynamometer, the pressure by the left hand arose from 29.6% on March 7 to 42.3% on March 20; while the practice was all with the right hand, whose strength arose from 28.8 to 48.6 in the same time.[4]

Simon noted the curious fact that practice in judging with both eyes brought with it but little betterment in judging with either eye alone; but when the left eye had been practiced by itself to its maximum powers, then the right eye also, although itself unpracticed, was nevertheless found to have advanced to its maximum.

[1] Swift, *American Journal of Psychology*, XIV, p. 201.

[2] Swift, *American Journal of Psychology*, XIV, p. 220.

[3] Scripture, *Yale Psychological Studies*, Vol. II, p. 114.

[4] Scripture, *Yale Psychological Studies*, Vol. II, p. 118.

[4] *Popular Science Monthly*, Vol. 56, p. 589.

"Practice with the left hand helped the right hand also,"[1] as is shown by the following table:

	40	120	200
Before	3.1	3.9	7.1
After	.07	3.8	6.6

"There is no appreciable improvement at the rates for which the left hand had not improved. These results show (1) that the transference from one side to the other—a transference which has been established in other investigations as taking place from the right side to the left—also takes place from the left to the right; and (2) that it is not mere practice that has this effect, but only *successful* practice."

From these experiments on cross-education, the following may be said: There may be a carrying over of training effects from one side of the body to the homologous members on the other side; these effects may be either in the form of skill, or force. In some cases there is no transfer; in some a negative transfer, or loss. There are indications that the "common element" is quite as much mental (knowledge of method or direction; attention), or objective, the likeness of the external situation, as that it is physical. The failures and losses are as important for a correct theory as the success.

Correlation.—The chief evidence which anti-formalists bring forward is the seemingly convincing one of the manifest differences among people as we find them. If a man had a good memory for tones, but a poor one for colors, one who believes in a "memory faculty" might consistently explain this variation as due to the differences in the nature of the stuff—tones being easier to retain than colors. But if that were the explanation, all people should be better in committing tones to memory than in memorizing colors; and increasing one's skill in doing one thing should give a corresponding increase in doing the other. To prove this false seems a work of supererogation, so plenteous are the human refutations all about us. There are,

[1]Woodworth, *Psy. Rev.*, Monograph Series 3, p. 104.

however, as is well known, studies by Wissler, ([1]) Aikins, ([2]) Thorndike and others, ([3]) which, even after their results are corrected for attenuation, as shown by Spearman, ([4]) show the thorough-going lack of complete correlation.

Data from the Education of Extreme Types. Some side contribution bearing on this problem comes from the education of the extreme types. When we are dealing with the average man who is fairly well equipped with the abilities society demands, it is easy enough to make assertions both ways. On the one side the formalist can point out the numerous men who have taken the straight old line college course and who have gone into the most diverse occupations and succeeded, and say, "See what his Latin, mathematics, etc., did for him; and further, he will point to the tradesman, the artisan, the clerk, who has not had the intellectual training given by the college course. His opponent, some Herbartian, perhaps, will reply that the first men had such native talents that they would have succeeded in any case; that they went to college as they wore certain clothes, because it was the thing to do among their set, and that since all, or most all, bright youths aspired to go to college, naturally enough the colleges produced great men.

But it is different with the abnormal classes, where the effort of the schools is to make them normal, and where the efforts are more or less measurable. As is known, idiots and young criminals were until quite recently considered hopeless and treated accordingly. However, men with the opinion of Dr. Seguin([5]) have held that many such seemingly hopeless cases were merely instances of undeveloped conditions, and as Beneke had held in the early part of the century, so conceived of education as the removal of hindrances, the opening up of

[1] *Psychological Review*, Monograph Supplement No.

[2] *Psychological Review*, Vol. IX, pp. 374 ff.

[3] *Columbia Contributions to Philosophy, Psychology, and Education*, Vol. IX, passim.

[4] *American Journal of Psychology*, Jan., 1904.

[5] Rooper, *Educational Studies and Addresses*, ch. I.
Seguin "On Idiocy."

avenues, the removal of limitations. So Dr. Seguin began by merely exercising the limp, flabby hand of the imbecile, massaging the muscles, moving the arm up and down. Then he gave the children incentives at first for doing physical movements. From these simple bodily processes, the steps are to easy mental requirements. So finally the clouded and atrophied tracts become open, both for the reception of sense stimuli and transmission of motor impulses. Often there would be freedom of innervation, but control would be wanting. "The eyeballs would roll from side to side with a short uneasy motion, and the range of their movements was small." By selection of proper exercises, these irregularities were often brought under control. In this way a higher intellectual life was made possible. The transfer was in giving even what normal abilities the child had, a fair opportunity and in putting some links in the chain of accomplishments. "Arrested development must be taken to mean unequal arrests." "There are ten per cent of imbeciles above the median in memory, and nine per cent in intelligence tests."(1) Johnson(2) points out that retentiveness is not a prominent factor in feeble-mindedness. More than 15% of imbeciles are equal to average children in tested mental traits.

These quotations from studies on imbeciles, who differ from the average person only in degree, support two assertions:— First, that "the normal intellect depends upon the interaction, and proper co-ordination of various parts of the nervous system," which same parts can be more or less effectively put together by the processes of education; and, second, these "powers" or "faculties" of the weak-minded are of unequal strength, and show no tendency to bring up the wanting faculties or abilities. To further refine the first conclusion, it means two things: that the education of the socially incompetent consists in the acquirement of certain habits or co-ordinations which are of more or less general applicability, and will so make them tolerable by society and partially self-supporting, and again that these newly formed habits and opened pathways make it possible for their

[1]Norsworthy, *The Psychology of Mentally Deficient Children.*

[2]Johnson, *Education of the Feeble-Minded.*

more normal capacities, previously hemmed in and hampered, to find expression.

The history of the reformation of criminals has run a parallel course with that of imbeciles. They were judged to be all bad, and hopelessly so. Now, we think with many, if not all, that both statements are false. The phrase "honor among thieves" indicates but one of many virtues which thieves may possess. Their feelings may be very tender under certain exciting situations, and completely lacking in others. Criminals are often very religious, have keen aesthetic appreciations, and yet are morally insensible. Their judgments and intuitions are often very alert and refined in one line, but without efficiency in others.([1]) Their courage is superb, often under the most terrible circumstances; and under others, their timidity, fear and cringing are despicable. Heredity and training seem to accentuate in them all sorts of differentiations in mental traits; and their training is often of the hardest and most successful sort.

Nor are they hopeless. They seem so to be under the formal disciplinist conception of education, which makes them dress alike, march in line, go to bed and get up at a certain minute. The requirements in penitentiaries are military: minute, exact, orderly. This, it is presumed, gives the prison habitues the habits and ideas of accuracy, promptness, obedience, respect, neatness, orderliness, industry. True it is that the inmates do for years these very commendable things; and to an onlooker who sees these men making such records as any martinet might be proud of, the prison system seems truly to be a great human reformatory. But it is only in the seeming; the facts are very different. Few of the men are made better, and most of the youths much worse. So now there are coming into existence such institutions as the George Junior Republic,([2]) and the Elmira Reformatory ([3]), which abandon the doctrine of formal discipline and so employ an entirely different scheme of

[1]Havelock Ellis, *Criminology*, ch. on Psy. of Criminals.

[2]George Junior Republic, *World's Work*, Vol. II, p. 1296.

[3]Winter, *Elmira Reformatory*, N. Y., p. 2.

education. It rests on two notions: first, the inmates are to acquire the knewledge and ideals of the better people of the larger world outside, and get the habits and modes of action which they will need in that larger life; second, to get these the prisoners are organized as far as possible into a type of society at large, in which the means, methods, motives and rewards are duplicates of those which will be needed when out of the prison.

In a word, on the negative side, they have abandoned the cultivation of reason, of the will, of the emotions, of the habits of order, of obedience, etc., and they train individuals to do the particular things they need to do, to think and feel in the particular ways that will be desirable for them, and finally to know the particular things they need to know.

These institutions are successful as the records of the "graduates" for ten years show only a very small per cent that go back to their former wayward life.

New Experimental Data

The first experiments to be reported are two on the practice effects of memorizing, which were carried on, from the point of view of method, in the manner of those of Professor Wm. James on this same subject, except that the material was more varied. Subject K's preliminary and final test series were with rows of figures, each prepared by a different person, and the practice was on poetry; subject B's tests were with names of places, the practice in poetry.

First experiment: Subject K. committed to memory five rows of figures, thirty figures in each row, at the rate of one row per day. This was the first test. The final test was also for five days, one row per day of thirty figures. The training was carried on for four weeks and consisted of memorizing sixteen lines per day from "In Memoriam." The data are given with curves. Fig. I.

But one figure in the first test is as low as the highest in the final test. The absolute difference in the two series is 28 minutes, or 58% of the time of the first test. The average saving for each trial is 5.6 minutes on an average time of 9.6 min-

utes in the first series. Furthermore, the final test does not continue to fall as if it were part of the practice curve started in the first test. It may be that there were certain figure combinations in the first test which offered peculiar difficulties to the subject. Of such she was unaware, for she felt no special obstructions in one group more than in the other. No doubt the habit of doing this sort of mental work at a certain period each day, and the passing away of certain mental confusions which at first operated, were large factors, possibly sufficient to account for the difference. On the other hand, it is quite probable that the failure of Professor James' subjects to improve was due to their mental poise and "at-homeness" in doing just such work.

The more specific directions for subject B. in the memory test were as follows: (1) Write out five lines of names of places, with fifteen names in each line, and commit one line each day for five days. The record for the time was kept in minutes, and will be found with Figure 2. (2) Two stanzas of "Faerie Queene" were committed then, every day for five weeks, the record again being carefully kept. (3) Again five lines of names of places, fifteen in each line, were memorized, at the rate of one line per day.

By reference to Fig. 2, it will be seen that the work was done in a shorter time, the absolute difference being four minutes, or 22% of the time of the first test. The first test is too brief to give, thinkably, any practice effect that would extend over the five weeks of interval. It is possible that the reflex from the learning of the poetry came in the form of a mental preparedness for doing that kind of thing each day.

The possible increase in the ability to remember figures, could readily come from the special training in doing that very thing in so many subjcets of the curriculum.

On the whole, then, an increased efficiency has come from these four years. It has been small for the most part; less than could be secured by a few days of direct training. So as a by product of their particular courses, while it is definite and possibly all that could be expected, it is almost negligible.

The second experiment concerned the improvement brought

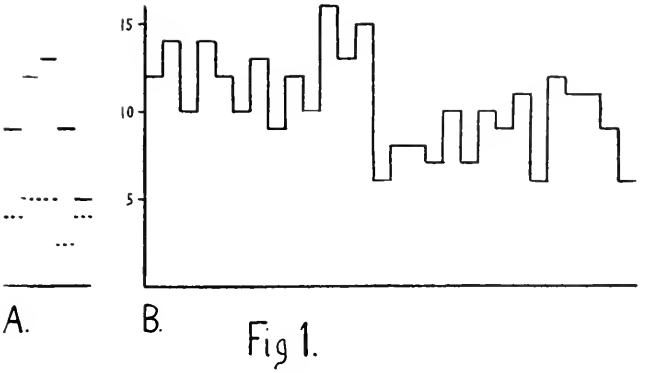

Fig 1.

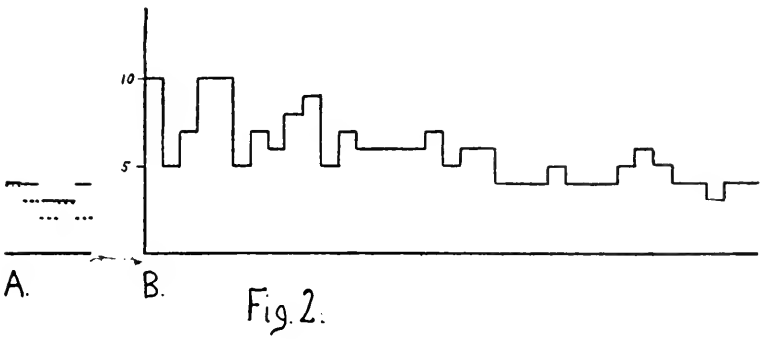

Fig. 2.

FIG. 1. Improvement of memory for figures due to practice in memorizing poetry. Subject K. A shows the ability in memorizing figures (inversely, by the time taken) before the practice (solid line) and after the practice (dotted line). B shows the course of practice (by the time taken) in memorizing poetry. The times required for learning 30 figures were: before practice, 9, 12, 13, 9 and 5 minutes, after practice 4, 5, 5, 2.5 and 4 minutes. The times required for learning 16 lines of "In Memoriam," were: in order, 12, 14, 10, 14, 12, 10, 13, 9, 12, 10, 16, 13. 15, 6, 8, 8, 7, 10, 7, 10, 9, 11 6, 12 11, 11, 9, 6 minutes.

FIG. 2. A and B mean the same as in Fig. 1 except that here the record is that of Subject B. The times required for learning 30 figures were: before practice, 4, 4, 3, 3 and 4, after practice, 4, 3, 2, 3 and 2. The times required for learning 2 stanzas of the "Faerie Queene" were, in order, 10, 5, 7, 10, 10, 5, 7, 6, 8, 9, 5, 7, 6, 6, 6, 6, 7, 5, 6, 6, 4, 4, 4, 5, 4, 4, 4, 5, 6, 5, 4, 4, 3, 4, 4 minutes.

about in the discrimination of length by the eye as a result of practice in discriminating length by the knowledge gained from arm movements. There were two subjects, S. and D.

The practice with both subjects was done with the following instrument: Into a narrow upright frame were fixed two parallel horizontal steel rods, about two feet long and one and one-half inches apart. On the lower rod were two spools fixed immovably at 25 cm. apart, and on the upper rod were two spools which were freely movable. Subject S., being blindfolded, passed the index finger between the fixed spools, without touching the rod; and having thus secured the space-image, adjusted the upper spools as nearly as he could at an equal distance. In half of the cases of each day's practice, the movable spools were shifted to a distance greater than the norm; and in half, to a distance less than the norm, preparatory for their adjustment by the subject. After each adjustment, the upper spools being held, the lower ones, by means of a slight contrivance, were brought up against the upper ones, so that the subject S. could *feel* how much of an error he had made. The plan with subject D. differed only in that he touched the rod in the passage between the limits, thus getting both a motor and a tactile basis for judgment.

For the preliminary and final tests for both subjects D. and S. the judgments were on the same sort of material, though the apparatus was not the same in both cases. A single black strip, 25 cm. in length was exposed for a definite time; following this, another of indefinite length was exposed, and then modified until the subject pronounced it equal in length to the norm, 25 cm. In half the cases the indefinite strip was longer to start with than the norm, and half, shorter than the norm.

In both practice and test series, it is to be noticed that the norm was of the same length, the judgment in the former being wihout any help from the eye, in the latter with such help.

The measurements are given in Table I.

TABLE I

ERROR IN MILLIMETERS IN DISCRIMINATING LENGTHS. EACH FIGURE EQUALS AN ALGEBRAIC SUM

Subject D			Subject S		
Test series With the aid of the eye		Practice series Without the aid of the eye	Test series With the aid of the eye		Practice series Without the aid of the eye
Before training	After training		Before training	After training	
		232			248
		104			144
		134			136
120	163	98	142	100	134
125	162	118	200	140	82
169	187	107	184	103	147
171	193	80	124	113	147
179	172	111	107	120	
175	181	166	152	91	
178	191	150	89	109	
171	294	82		122	
196	254	107			
238	213	121			
218	243	80			
290	297	105			
	213	87			
	204				
	207				
Medians					
177	204		142	111	

These figures represent the average of five different records, that is, the actual data consisted of five times as much as is represented in the tables. The practice effects in the practice series are not very great, though more pronounced in S. than in D. One reason for this may be that both subjects were skilled experimental psychologists, who as students and teachers had drilled themselves into many forms of movement. This is further suggested by the curve rising rapidly at first, which probably represents their period of getting acquainted with a novel form of apparatus. This acquaintance being secured, actual physical dexterity grew slightly. Another reason for this low degree of increase was the hardness of the test. The fact of being blindfolded added confusion by breaking out of the chain an ordinary associate in judgments of extension. Then, the principle of judgment with S. was very unusual; *viz.*, deciding a length on amount of space *passed through*, without touching anything. It was so wearing on the subject that it could be kept up but a few minutes at a time. This weariness was not so great with subject D., who used the ordinary means of touch in measuring the length.

Concerning the main issue, the result of the experiment is negative. One subject showed improvement in the tests after training; the other was, to an equal degree, inferior.

The third set of data are figures showing the improvement after four years' college education in certain mental capacities. These figures are derived from the tests made at the Columbia University Psychological Laboratory, on students when they entered as freshmen, and again on the same students as seniors. This material is fully described by Dr. Clark Wissler in "The Correlation of Mental and Physical Tests."[1] Those selected for comparison in this study are the tests on (1) perception of pitch, (2) perception of letters at different distances with (a) right eye, (b) left eye; (3) reaction time; (4) rate of perception in marking the letter "A" in a prepared page of mixed letters; (5) auditory memory for figures; (6) memory for a simple passage; (7) quickness in naming different colors.

[1] *Psychological Review*, Mon. Sup., No. 16, p. 4.

In discrimination of pitch there was a slight gain, there being 57 cases of improvement, 32 of deterioration, 9 of no change, a median gain of 1 point, which means a reduction of the amount of error by about 15 per cent. The details are given in Table 2.

In sharpness of vision, there was no demonstrable change, though (counting both eyes' records) there were 137 cases of improvement to 78 of deterioration, 71 cases showed no change, bringing the median to 0 gain. The average of the senior records is slightly superior. The details are given in Tables 3 and 4.

In reaction time there was a slight gain, 77 of the senior records being shorter, 61 longer than the early records, and 2 being equal. The median gain was .006 sec. or roughly, 4 per cent. The details are given in Table 5.

In the rate of marking A's. on a printed sheet of capital letters there was clear improvement of roughly 10 per cent. If only those cases are taken where the number of errors in the early equals that in the late test, the shortening of time measures improvement. The result of the calculation is a median diminution of time of 11 seconds. The details are given in Table 6.

In auditory memory for figures there was no demonstrable change, though there were 60 cases of improvement to 38 of deterioration, and the average of the senior records was slightly better. The median tendency was, however, to no improvement. The details are given in Table 7, in which the upper and lower of each pair of figures represent respectively the freshman and senior records of one man.

In memory for a simple passage, there was no improvement. Sixteen did better, 15 worse, and 8 the same in senior as in freshman year. For details see Table 8.

In naming colors there was a median gain of 11 seconds or roughly 15 per cent. 22 individuals improved and only 5 got worse. For details see Table 9.

One of the cases in which improvement might be rationally expected was that of so-called logical memory, or the memory of a simple passage. However, it was there the very least, the movement being in the positive direction, but within the zero

TABLE 2

DISCRIMINATION OF PITCH. NORM 75

The nearer the figure to 75, the better the record. The upper figure of each pair is the Freshman record in this and later tables

71	75	65	76	72	57	74	74	80	61	77	63	71	74	78	75	66	66	72	62	70	70
75	76	50	80	56	80	80	75	75	76	73	71	79	76	69	73	73	58	71	65	73	72
72	78	54	72	67	77	74	73	65	69	64	39	93	72	72	76	86	73	68	73	60	66
77	75	72	75	69	76	78	75	49	64	75	75	70	76	72	90	59	74	75	74	68	78
73	73	75	63	55	74	63	83	77	76	74	78	75	62	52	71	61	73	88	62	71	74
84	75	75	60	70	74	57	74	77	73	74	56	74	47	87	74	78	72	76	62	75	75
85	62	73	78	95	67	64	69	61	75	87	59	74	75	54	87	73	66	72	66	72	73
71	75	74	70	73	76	74	71	84	76	70	73	75	72	75	75	78	75	73	62	76	74
67	74	52	74	66	52	70	75	54	74	68											
85	76	76	78	85	74	76	74	73	71	74											

Number improving 57 Av. increase 8
Number stationary 9
Number decreasing 32 Av. decrease 5

TABLE 3
SHARPNESS OF VISION—OF RIGHT EYE
The higher the figure, the better the record.

26	52	34	61	61	37	52	40	52	37	44	37	37	52	52	61	52	72	61	22	72	61
26	61	37	80	61	50	52	52	61	52	85	44	52	44	72	72	61	72	52	22	72	65
61	61	37	52	31	61	52	61	52	44	72	61	61	52	52	61	52	36	69	37	72	61
72	37	52	70	31	72	60	60	52	70	61	72	61	52	37	44	52	52	61	52	72	100
61	52	52	61	70	44	50	44	44	52	61	61	37	48	68	72	52	61	52	61	61	44
52	60	52	70	61	61	44	26	61	52	61	61	30	52	72	72	40	72	52	58	52	52
72	61	52	72	61	61	44	52	44	44	37	37	52	72	58	32	61	60	44	52	52	42
52	72	44	68	61	52	61	61	40	37	31	31	44	58	72	52	58	82	44	70	61	61
44	61	61	60	37	31	52	50	44	61	52	22	56	52	37	72	14	52	37	61	44	14
50	48	61	60	44	26	60	52	61	61	72	22	85	44	52	85	14	72	37	61	61	26
26	37	61	48	31	22	52	61	52	50	37	52	31	37	52	61	61	52	61	52	44	31
26	61	52	61	52	19	61	61	61	61	44	61	52	52	58	61	72	61	61	61	44	37
52	37	31	37	49	61	52	52	52	44	52	52	37	61								
52	52	52	44	52	72	52	61	52	68	72	44	44	52								

Number improving 75 Av. increase 13.5
Number stationary 35
Number decreasing 35 Av. decrease 10.0

TABLE 4

SHARPNESS OF VISION—OF LEFT EYE

The higher the figure, the better the record

52	52	44	52	52	61	61	52	61	26	61	62	31	52	31	61	70	44	58	50	61
72	84	52	72	37	72	72	72	72	19	60	52	31	61	44	72	61	50	52	44	60
61	61	37	61	31	72	50	72	61	61	61	72	72	52	37	61	52	52	37	52	61
61	37	44	61	31	72	44	70	52	58	61	72	61	52	44	31	37	61	52	72	85
61	50	52	52	61	52	52	44	52	61	61	61	26	52	61	72	37	61	52	72	61
52	54	48		61	61	44	37	52	52	61	52	20	44	72	61	37	72	44	58	52
58	61	72	52	85	61	61	61	44	52	44	39	52	37	37	72	72	61	32	52	61
52	61	61	44	68	72	52	52	52	48	61	40	37	37	37	44	61	61	52	52	85
44	72	61	42	44	42	52	50	37	26	52	60	52	52	52	26	56	44	37	70	44
44	69	71	60	60	52	60	60	52	26	52	22	66	72	61	22	85	44	85	85	72
36	44	52	31	26	44	61	48	37	26	52	52	52	52	44	52	39	37	44	72	61
36	52	61	31	24	61	61	61	52	19	61	52	61	52	44	61	52	48	44	72	27
52	91	61	37	31	44	44	31	52	31	44	52	44	52	44	44	44	52	52		
72	91	72	44	26	52	61	37	44	52	61	52	61	52	58	72	44	37	52		

Number improving 62 Av. increase 13.5
Number stationary 36
Number decreasing 42 Av. decrease 10

TABLE 5

REACTION-TIMES, IN TERMS OF .001 SEC.

The lower the number, the better the record

178	115	183	211	123	159	147	195	133	115	166	131	136	121	120	135
137	157	114	153	139	119	198	193	152	114	154	166	132	148	127	148
128	148	143	148	206	184	195	144	138	240	176	175	125	186	201	148
167	173	180	148	204	132	127	196	135	141	167	137	216	188	129	222
132	172	179	210	133	134	130	153	148	198	236	146	205	180	195	159
178	195	152	204	138	155	110	165	274	171	190	159	183	177	139	132
190	167	141	135	184	123	146	130	165	122	131	141	149	187	99	127
145	183	169	133	166	156	156	180	145	133	146	143	129	196	144	186
140	141	125	162	158	128	146	114	164	155	115	133	132	169	171	202
120	186	178	180	138	142	148	234	157	162	200	157	120	131	133	198
152	148	169	178	134	178	211	172	157	178	145	189	175	133	344	112
178	125	284	148	134	141	149	165	135	153	170	187	155	241	169	228
150	229	151	205	268	163	155	200	145	133	152	165	169	186	173	195
149	148	130	161	182	152	167	230	137	138	143	131	163	146	154	215
179	143	148	373	233	154	150	162	182	173	155	100	161	247	124	100
143	150	102	106	181	159	134	122	129	161	183	131	165	142	105	105
151	171	156	208	151	123	160	176	161	144	147	124				
175	112	170	117	161	147	121	165	107	130	139	123				

Number improving 77 Av. improvement .036 sec.
Number stationary 2
Number decreasing 61 Av. loss .034 sec.
Median change .006 sec. i. e. a gain of .006 sec.

TABLE 6

RATE OF PERCEPTION. A's in a page of letters

The time taken to mark 100 and the omissions, if any

85-2	90	82-3	100-1	69-6	85	100-0	87-0	77-0	148-0	95-1	98	114	85	104-0
75-2	89	80-0	80-4	69-10	62	87-0	110-0	76-1	160-0	72	92	60	90	90-0
100-0	114-0	140-1	125	60	105	90	85	96-16	115-0	84-11	94-2	88-3	67-10	95-3
82-0	103-4	100-2	98	59	74	89	54	92-2	81-4	74-4	88-2	90-0	70-0	91-5
90-1	80-3	70-2	82-3	115-0	92-1	115-0	85-5	135-0	90-2	111-16	75-3	115-2	86-1	86-1
75-2	67-1	68-0	126-0	107-1	90	123-0	74-2	111-0	70-0	93	51-2	112	70-1	82-2
110-2	80-1	98-1	117-0	93-0	103-3	83-3	89-0	108-1	120-0	72-8	88-6	95-0	87-2	90-1
118-0	70-0	98-0	84-1	90-0	86-1	95-0	85-0	89-7	92-1	69-2	81-1	127-0	71-0	75-1
77-10	125-0	122-0	110-4	100-0	105-2	96-3	132-1	70-1	60-14	103-2	101-1	112-8	124-1	146-0
78	112-0	85-0	80-0	80-1	85-1	95-2	75-1	81-0	115-4	79-3	86-1	90-2	146-1	113-3
	120-1	95-5	93-12	115-0	71-0	80-7	93-3	87-1	95-7	89	73-3	95-11	89-2	68-2
	139-0	105-0	97-0	70-4	72-0	80-1	81-1	80-0	102-0	56	74-2	71-7	74-2	68-1
	78-12	133-3	107-1	105-2	83-2	80-2	115-2	108-2	95-2	80-11	102-5	122-0	55-42	89-1
	61-7	122-7	96-0	83-1	80-3	80-3	107-0	100-1	104-1	66-5	89-1	111-0	75-16	85-3
	100-1	96-2	80-1	110-0	93-0	107-0	110-2	90-3	110-3	99-4	100-1	145-1	87-0	72-4
	110-1	83-1	65-2	84-1	82-0	76-0	87-0	78-1	82-0	90-0	79-2	107-1	98	72-2
	121-0	82-0	96-1	90-2	95-5	90-4	94-0	93-23	163-4	75-8	106-0	79-4	89-6	89-0
	115	59-4	22-0	93-0	70-0	78-2	74	100-9	130-1	84-1	89-1	69-1	81-1	68-1
	75-5	99-3	61-2	75-0	82-5	96-3	71-8	82-1	83-4	97-0	128-0	85-2	95-1	76-1
	76-5	86-16	92-4	73-3	67-7	87-1	67-3	82-1	111	70-1				

USING ALL RECORDS

Number improving 104 Average improvement 17

Number stationary 7

Number deteriorating 33 Average loss 13.6

USING ONLY UNAMBIGUOUS RECORDS

Number improving 29

Number stationary 1

Number deteriorating 10

Medium improvement 11 seconds

TABLE 7
AUDITORY MEMORY—FOR FIGURES
The larger the score, the better the record

4	8	3·3	6.3	8	7.3	7.6	7.3	6.3	3.3	8	5.3	5	5.6	6	6.6	8	8
5.3	8	7	8	8	7.3	8	8	7.6	6.3	8	5.3	7.6	7.3	7.3	5	8	8
6.5	5.3	8	7	7.3	6.3	5.7	7.6	8	8	6.6	8	6.6	6.6	7.6	3.3	6	7.6
4.7	6.7	8	6	8	7.7	5	8	8	8	6.3	8	8	7.6	8	6	2.6	8
8	6.6	7	8	7.6	8	7.3	5.3	5.6	8	4.3	7.6	7.3	6.6	8	7.3	8	8
7.7	6.3	7	8	8	8	6.6	2.6	4.6	3.7	7.7	8	8	6.4	8	8	8	7.6
6.6	8	7	8	6.3	8	7	6	6.3	8	7	7.6	6.6	7	5	5.6	8	7.6
8	7.6	7	8	7.6	8	7.6	7.3	7.6	7.6	7.3	7.6	7	7	8	5.6	8	7
7.5	7	7.3	7.3	8	8	6.6	7.3	4	7	6	8	6	5.6	7.6	5.6	7.6	
7	7.3	4	7.6	8	8	7.6	7.6	5.6	7	7.6	7	7.3	7.3	7	4	7.3	
6.3	8	7.6	5	7	7.6	8	7.6	7.6	7.3	7	5	6.6	5.6	6.6	5	5.3	7
6.3	8	7.3	6	7.3	5.6	8	7.3	8	7.6	8	5.6	8	5	6	5.6	6.3	5.6
8	4.5	7.2	5.3	8	5.3	7	8	8	6.7	7.6	4.3	7	5.3	7.3	3.3	6	6
6.6	6	6	7.6	7	5.3	6.6	8	8	8	6.6	5.3	7.6	7.6	7.3	7.3	8	7
7.3	7	6.6	8	4	7	8	7.3	7.3									
8	7	7.3	8	6	6.6	6.3	8	8									

Number improving 60
Number stationary 11 (+ 22 cases of 8-8)
Number deteriorating 38

Average increase .5
Average decrease .4

TABLE 8
LOGICAL MEMORY: Memory of a Simple Passage
The higher the numbers, the better the record

4	6	5	9	5	7	3	2	6	5	3	4	5	3
4	4	5	8	6	5	3	3	6	5	4·5	3	5	7
5	1	6	5	0	4	6	5	9	2	3	3	3	2
5	5	5	3	5	5	3	3·5	5	4	4	5	6	3
5	3	7	4	1	4	5	2	8	6	5			
2	4	6	3	5	5	3	4	8	5	4			

Number improving 16 Av. gain 2
Number stationary 8
Number decreasing 15 Av. loss 2

TABLE 9
NAMING OF COLORS
The lower the figure, the better the record

77	67	82	58	82	67	72	108	73	105	90
59	54	85	55	70	50	70	88	66	80	65
48	63	60	150	69	75	76	76	85	112	70
55	64	51	82	67	63	58	77	64	155	60
80	75	90	65	85						
71	64	85	53	69						

Number improving 22 Av. gain 15
Number stationary 0
Number deteriorating 5 Av. loss 11

limit. Presumably the increase which the four years of college work has given is along some special line or interest. This agrees with the tests on this same point on men of science carried on January, 1905, Philadelphia, at the last session of the American Association of Science, by Mr. F. G. Bruner.

Men of Science, Logical Memory 3.55 points out of 8.
College Freshmen, " " 4.45 " " " 8.

As is seen, these famous men cannot remember the thought of the few sentences given in the test better than beginning college students.

The only clear gains in the four years are in the speed of the ability to pick out and mark the letter "A" among other letters, and to recognize and name a series of different colors. Both imply added control of perceptive and motor connections, one in the eye-hand complex, and the other in the word area. The second test was only in a small degree a test of the quickness of color discrimination; the hesitancy was over the name for the color. There was such a quickening, however, as was referred to above.

The fourth series of experiments shows the result of special practice in discriminating different saturations of blue upon other sense powers in the case of sixteen children from the Speyer School of Teachers College. They were of average intelligence, and none of them had had any special training in color. They were about eleven years old. A Milton-Bradley color wheel was used, with a set of the larger and smaller disks. Two of the smaller disks, of different colors, *e. g.*, blue and white, were adjusted so that there was a fixed per cent of the blue and of the white. The outer disks were of the same colors but were shiftable, so that the amount of blue could be increased or diminished at will. When the disks revolved the inner disk presented a blue of one degree of saturation, and the outer disk another. The amount of this difference was indicated on a scale-disk. The children recorded their judgments with an "I" or "O" according as the saturation of the inner disk, or outer disk, was greater, or with an "S," if it was the same for both.

The preliminary and final tests were in discriminating

different mixtures (1) of red and white, (2) of yellow and green, (3) of orange and black. There was also, a preliminary test in distinguishing differences in pitch.

Finally these children were tested in discrimination of length, in marking A's and in accuracy of movement.

The practice was continued on Tuesdays and Thursdays at 2 p. m., for a half hour, through the period from October to March, and was done with the blue and white disks. In all this color work, the method of minimal gradations was employed, since it permits a class experiment. The children occupied the same relative positions to the color disks through the series and as far as possible, the light was maintained the same by use of shades.

The training with the Speyer School children was very definite, and gives some very clear results. With the boys, the range within which the two tints of red were judged the same, was from 2.3° to 4.5° at the first test (See Table 10). The 2.3° as opposed to the 4.5° represent the practice effects that came in during these preliminary trials. When these disks are returned for the final test, the range is from .6° to .9°, (A. D. .2 to .4). This difference can hardly be considered to be a continuation of the rapidly descending first line, for, first it starts in much lower (1.9°), and, second, with the brief experimental period at first, it was not likely that the habit should have persisted through four months of complete inattention to these particular colors. Again, the first line is a falling one, the last figures not indicating that the level of skill has been reached, and that it would fall further may be inferred from what happened with the practice curve for blue and white, which likewise started in at 4.5° and fell to an average level of 1.°. But the second line is not a falling line, seeming to be simply the continuation of a level line of skill.

These same statements are perfectly duplicated in the case of the girls on the same test (See Table 10); and for the boys, with yellow and green (See Table 10). The only variation from this in the other two cases—girls with yellow and green (See Table 10), and boys with black and orange (See Table 10), is that the first curve indicates that practice effects had not ap-

TABLE 10

THE INFLUENCE OF SPECIAL TRAINING IN SENSE DISCRIMINATION

Tests with red and white

Boys.	Before training	Avs.	4.5	4.5	3.0	3.2	2.3
		A. D's.	1.1	1.5	1.2	1.0	0.9
	After training	Avs.	.6	.7	.9		
		A. D's.	.4	.2	.3		
Girls.	Before training	Avs.	3.5	6.0	4.2	3.4	2.4
		A. D's	1.0	1.5	1.1	.9	.9
	After training	Avs.	.48	.75	.65		
		A. D's.	.2	.3	.2		

Tests with yellow and green

Boys.	Before training	Avs.	6.7	5.3	4.0		
		A. D's.	1.0	1.5	1.0		
	After training	Avs.	2.0	2.0	1.3	3.0	
		A. D's	1.0	1.2	.5	.8	
Girls.	Before training	Avs.	5.0	5.2	5.0	5.1	
		A. D's	1.8	1.4	1.2	1.1	
	After training	Avs.	2.8	2.6	1.7	1.7	2.1
		A. D's	.9	.8	.6	.5	.9

Tests with black and orange

Boys.	Before training	Avs.	3.0	2.8	3.4		
		A. D's.	.7	.7	.5		
	After training	Avs.	1.2	1.6	.8	.9	1.0
		A. D's.	.6	.6	.2	.5	.1
Girls.	Before training	Avs.	2.7	2.7	2.2		
		A. D's.	.8	.5	.3		
	After training	Avs.	1.8	1.3	.9	5.	.5
		A. D's.	.5	.7	.3	2.	.2

Tests with pitch

Boys.	Before training	Avs.	6.2	4.0	4.5	5.1	6.6	3.0
		A. D's.	2.0	3.0	2.0	1.8	3.0	2.0
	After training	Avs.	4.6	4.3	2.3	3.0	3.0	4.0
		A. D's.	1.1	.9	.9	.8	.8	1.5
Girls.	Before training	Avs.	5.4	7.2	6.0	6.4	3.6	3.2
		A. D's.	4.0	5.0	4.5	3.3	2.7	0.8
	After training	Avs.	4.5	5.2	3.2	3.2	3.4	5.3
		A. D's	1.4	1.3	0.7	1.0	1.1	1.2

Practice series with blue and white

Boys.	Avs.	2.7	2.6	2.4	2.0	1.8	.83	.6	.87	1.6	1.25	1.06	1.2
		1.4	1.35	.9	.8	.6	.7	1.1	.7	.7	.9	.8	
Girls.	Avs.	4.5	3.0	2.0	2.3	1.7	.9	1.1	.8	1.2	.65	.65	
		.7	.55	1.1	.84	.7	.7	.9	.7	.7	.5	.5	
		.6	.6	.4	.7								

peared at all in the beginning, thus more completely isolating the last curve. With the last curves—with girls with black and orange (See Table 10), is the only case where there was a noticeable practice effect in the final test. But here as in all the others, the lines are clearly separate throughout, and from their form do not indicate that one is a continuation of the other.

The average deviations for each case are given and in all cases are so low as to indicate the high reliability of the figures, and the general uniformity of experience for all the children.

The practice curves (See Figs. 3 and 4, p. 65) present considerable irregularities, but if it is observed that the ordinate unit is 1-10°, these become smaller. During the practice with the blue-white series, the relative amounts of each were often changed, so that no certain tint could come to stand as a standard "same." But such changes in the sorts of blue to be judged did not modify noticeably the falling line, or the level line of skill. In brief, the ability to discriminate certain tints of blue was easily applied to other tints of the same color.

The indications are that the practice was carried on longer than was necessary to reach the skill limit, but the extended time threw the test series farther apart, and to that degree obviates the criticism to which so many tests on this subject are open, namely that the increase in skill was due to the training within the test series itself.

Before the practice with the blue-white series was begun, and just after it was closed, a test was made of the range within which the children could distinguish the pitch of two tones. The Gilbert Tone-tester was employed in the experiment. F sharp was taken as the norm, and the method employed, that of minimal gradations. As the figures (See Table 10) present it, the sharpness went from a range of 4.4 points at the first test—each point representing an eighth of the distance from F to F sharp, or F sharp to G—to one of 3.5 at the last test with the boys, or a gain of 20%; and from 5.3 points to 4.1 points for the girls, or a gain of about 23%. One thing can be said: that the improvement in the discrimination of pitch is not at all commensurate with that in the color field. It is not, however, tena-

ble to explain it as totally due to the ordinary singing exercises of the school that went on within the interim. Furthermore, the tones presented such difficulties that there was little practice effect, within either one of the series taken separately, so that the increase in skill must come from a source outside of tone influences. It may be in part due to the actual physiological development of the sensorium; but the amount of the difference is far too large for the growth of a four months' period.

The average deviations for both boys and girls are large and irregular, especially for the girls, in the first cases; but in the last cases, they are small, and much more regular, the A. D. of the average deviations for the boys being .2%, and .3% for the girls.

The fifth experiment was conducted in the following manner: On a drum which revolved at a given rate, was placed a series of parallel lines, which were exposed in succession, through a slit in a large card board. The alternate lines were the norm, 10 cm. in length; the intervening ones differed from the norm by amounts ranging from one to ten mm. By the method of right and wrong cases, the threshold of difference was obtained. This was followed by the practice series running through two months, four times per week. The same drum was used with the comparison lines covered up; then the norms only were exposed through the slit. By a mechanism attached to a motor, a wide ribbon of paper was made to move continuously between an upper and lower surface. In the upper was a long opening large enough to move a pencil point freely, transversely to the direction of the moving paper. The subject, then, when the norm appeared in view, endeavored to duplicate it, in length, on the slow moving paper, which immediately carried his made line out of view. So the skill was largely due to practice of the motor sense. The preliminary test was again given as the final one. There were two subjects, F. and W.

In order to give a safe range for judgment, and at the same time a sufficient number of judgments for each case, about 700 judgments were made in the preliminary series, using the method of right and wrong cases. When the line was 4 mm. longer than the norm, F. got nearly 25% of correct judgments

in the preliminary test, and when 4 1-2 mm. long, he obtained nearly 25% correct judgments in the final test.

Of the approximately one thousand judgments made in the practice series, the course of improvement may be indicated by a comparison of the first fifty with the last fifty. The average deviation from the norm of 10 cm., of the first fifty was 9.0 mm. and the A. D. of these deviations, 5.0 mm. For the final fifty cases, the average deviation from the norm was 1.1 mm., with the A. D. of these deviations 1.5. For subject W. there were 33 1-3% correct judgments when line was 3 mm. shorter than norm, and 25% when 3 mm. longer than norm; this in first test series. In the final series, the judgments were correct for 4 mm. longer, in a little more than one-fifth of the cases.

So, so far as this test is concerned, there was no transfer of training effects, from motor practice to visual practice, but rather a loss. This may be due to an actual failure to make the comparisons more accurate, or to reduce the variability. For the first fifty cases, the average of the deviations from the norm was 3.4 mm. with an A. D. of 2; whereas, for the final fifty the figures were 4 and 2.1. The subject was troubled by fluctuations of attention, the tendency to draw by force of habit and ignore the norm, and by certain Muller-Lyer illusions in length caused by the variation in the relation of the lines as each appeared, to the sides of the opening.

However the test itself is subject to criticism. First, subject W. was at the same time acting as a subject in another experiment which required judgment at sight on length of lines. This criticism stands on the question of fact, whether he had already reached the limit of his capacity. Subject F. likewise was having in his capacity as laboratory director, much training in the same field. So again the value of the data turns on the same question of physiological limit.

But more closely connected with the test is the criticism that the method of right and wrong cases necessitated so many judgments as probably to introduce extensive, if not fatal practice effects in the test series.

The sixth experiment was with business college students. It is well known that such students are serious, that their

increase in skill is very great, that it is measureable, and continuous, and that there is little other training obtained during the period. So just at entrance, and after three months' drill in touch typewriting, and in shorthand, the following tests were given, all but No. 3 being done in thirty seconds. In No. 1, (Fig. 5) the A's were to be marked; in No. 2, (Fig. 6) the maze was to be traced, the distance and number of touches on the sides being taken in consideration; in No. 3, (Fig. 7) the lines were to be bisected, and one drawn at the bottom of paper as long as the one at the top; in No. 4, (Fig 8) the dots were to be marked.

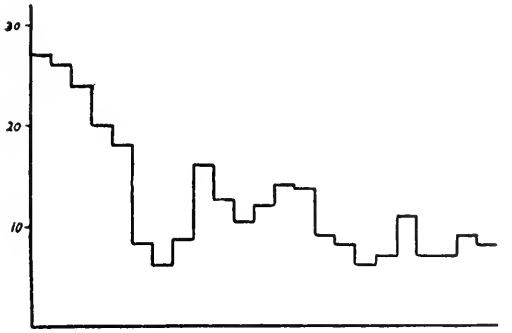

Fig. 3

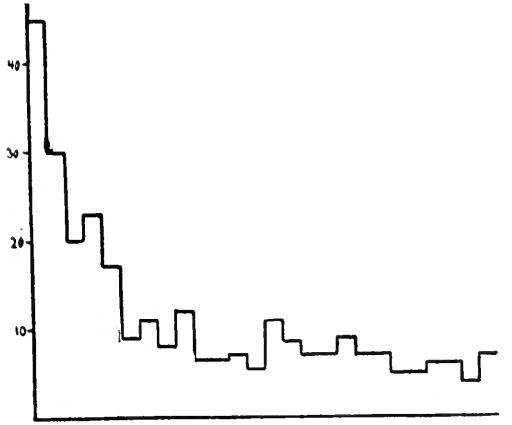

Fig. 4

Figs. 3 and 4. The course of practice in discriminating blues. The height of the line represents the inaccuracy of discrimination by the increase in the blue required (in tenths of a degree). The different practice periods are recorded from left to right in the time order in which they occurred. Fig. 3 is for boys; Fig. 4 is for girls.

OYKFIUDBHTAGDAACDIXAMRPAGQZTAACVAOWLYX
WABBTHJJANEEFAAM EAACBSVSKALLPHANRNPKAZF
YRQAQEAXJUDFOIMWZSAUCGVAOABMAYDYAAZJDAL
JACINEVBGAOFHARPVEJCTQZAPJLEIQWNAHRBUIAS
SNZMWAAAWHACAXHXQAXTDPUTYGSKGRKVLGKIM
FUOFAAKYFGTMBLYZIJAAVAUAACXDTVDACJSIUFMO
TXWAMQEAKHAOPXZWCAIRBRZNSOQAQLMDGUSGB
AKNAAPLPAAAHYOAEKLNVFARJAEHNPWIBAYAQRK
UPDSHAAQGGHTAMZAQGMTPNURQNXIJEOWYCREJD
UOLJCCAKSZAUAFERFAWAFZAWXBAAAVHAMBATAD
KVSTVNAPLILAOXYSJUOVYIVPAAPSDNLKRQAAOJLE
GAAQYEMPAZNTIBXGAIMRUSAWZAZWXAMXBDXAJZ
ECNABAHGDVSVFTCLAYKUKCWAFRWHTQYAFAAAOH

Fig. 5. Facsimile of Form No. 1.

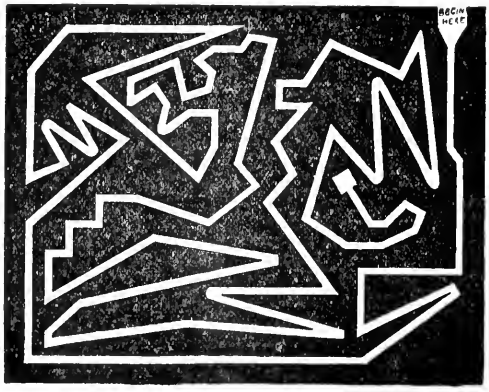

Fig. 6. Form No. 2 ; one-half actual diameter.

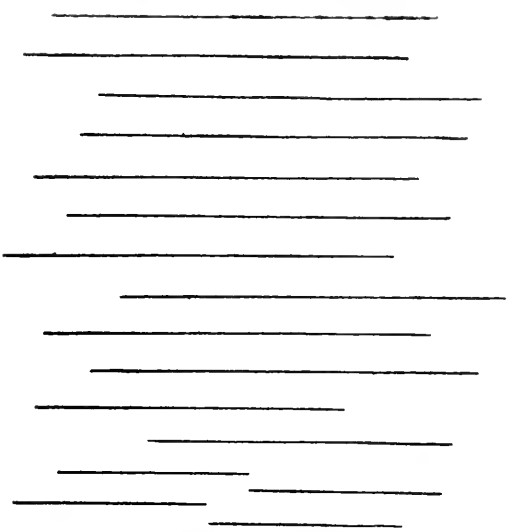

Fig. 7. Form No. 3; one-half actual diameter.

Fig. 8. Form No. 4; actual size.

The data are in two groups: The first, group I, is from students who were taken separately into a private room, and given all the time they needed to complete each of the tests. In group II the students were all in one room, and at a prearranged signal they began to mark the A's in Form I, and continued this for thirty seconds, when, the signal again being given, they all stopped. In this same way, and in the same length of time, they touched the dots, Form 4, and traced the maze, Form 2. They were not limited in time in bisecting the lines.

Group I. Here the time which each student took to mark all the A's in Form I, at the beginning of a three months' period, was recorded, and the differences, that is the losses or gains in seconds, determined. The following is a distribution of these differences, the minuses indicating the cases in which a larger time was used in doing the work, and the pluses, a shorter time:

−30, 0, +5, +8, +10, +10, +12, +20, +25, +29. The median, or middle number, is plus +10; that is, there is an absolute gain for the whole group of ten seconds. The distribution of the time in seconds taken to mark the A's in the first test, is 132, 125, 125, 115, 110, 110, 98, 90, 82, 75, 75. The median for the group is 110 seconds. Letting this stand for the time it took the group on the whole at the initial test, then the gain of 10 seconds would be 9 1-11%.

The A's omitted in this group, where full time was allowed, were so few as to be negligible.

The following are the time records in seconds for each student in touching the dots (See Form 4): 137, 126, 125, 122, 120, 109, 91, 85, 83. The median is 121. If from each of these numbers the times taken for the final test, in doing the same thing, are subtracted, this is their distribution: −7, −5, −3, −3, +6, +13, +24, +27, +29, +42. The approximate median gain is 9 seconds, or 7 5-12% of the original median time in touching the dots.

In the bisecting of the lines (Form 3) for group I, there are two factors—speed and accuracy. The data below show that the work was done more quickly, and at the same time there was

less variation in placing the bisecting mark from the true center. This first row of figures is the record in seconds for each student in the first test: 53, 25, 23, 23, 22, 20, 17, 17, 13, 13, 12. The median is 20. From the distribution of the differences for each student in the final test; viz. —1, +2, +4, +5, +5., +6, +8, +9, +9, +15, 25. The median gain is seen as 6 seconds, or in relation to the 20 seconds, it is 30%.

There were fifteen of the lines used in the test. By getting the difference between the half of each line, as the students marked it, and the real half, and dividing the sum of these fifteen differences by 15, is obtained the average error for each student. These are in mm.: 3.7, 3, 2.3, 2.3, 2, 1.7, 1.6, 1.5, 1.2, 1.1, .1. The median variation is thus 1.7. If from each of these is taken the amount in mm. which was added to the real half-line, on the last test, we have the following distributions of differences in the accuracy of the first and final test: —1.3, —.9, —.9, —.1, +.1, +.1, +.1, +.2, +.2, +.3, +1.2. Here the median improvement is .1 mm, or about 6%. This means that per cent of increase in skill in bisecting the lines.

The following are the records in seconds for each student in tracing the maze. There were only five who did this test: 72, 57, 42, 23, 20. The median is 42. In all cases there was a shortening of the time, as the following differences show: +3, +5, +9, +17, +17. The median change, or gain, is 9 seconds or 22%.

For the number of times each student touched the sides of the maze in the first test the following are the figures: 58, 52, 41, 23, 23. Median, 41. Differences between these figures and the ones for the final test: —22, —8, —1, +1, + 6. Here the minuses indicate loss of skill, that is increase in number of touches. The median gain in actual number of touches is 1, which is about 2%. If the touches increased exactly in the same per cent as the distance it could be said that their rate of speed only had grown. But it is quite probable that accuracy also was greater in the second case, not only because of the questionable difference of 2% in number of touches but because the number was not much greater, as the greater speed necessitates greater accuracy to keep from touching the sides.

Group II. As was said, this group was tested as a class, the time being common for them all except in the case of bisecting the lines. The maze (Form 2) is divided into thirty parts, all of which can be traced successfully, that is without touching the side, in approximately the same length of time. So the time factor is eliminated in this test, and the following distribution stands for the actual distances on this scale of 30 that each student traced at the initial test: 7, 7, 8, 8, 12, 13, 14, 14. The approximate median distance for the group then is 10. These subtracted from the records for the final test give the changes in skill for this act: —3, —1, +1.5, +3.5, +4, +4.5, +5.5, +14. The median gain then is about 3.7 which is 37% of the median accomplishment in the preliminary test.

The record of the number of times the sides of the maze were touched the first time, is: 0, 1, 4, 8, 12, 13, 31, 43. The median number is 10. There was an increase in the number of touches for the last series, as the following differences show: —5, +4, +8, +9, +11, +12, +24, +32. Median, 10, or 100% of the original median amount. This increase is in part a necessary correlation of greater distance, and consequently their improvement in the test as a whole is left undetermined.

As to the work of marking the A's by this group, the distribution is in terms of the number of A's marked in the thirty seconds by each student: 38, 41, 42, 43, 45, 62, 69, 77, 88. Median number is 45. These are the figures for the first test. The differences between this record and the final one are: —34, —23, —21, —17, 0, +9, +13, +20, +42. As the median is 0, there is no gain or loss, that is, the median for the last series was also 45, as well as for the first.

As to the bisection of the lines (Form 3), the averages of the deviations, for each student, of the 15 lines, from the actual half, in the first test are as follows: 0, 8., 1., 1.2, 1.2, 1.7, 1.8, 1.8, 1.9, 4 mm. Median, 1.7 mm. When these same 15 lines were divided three months later, the changes were —.5, —.4, 0, +.4, +.4, +.5, +.9, +1.2, +2.3. Median gain 0.4 mm., or 23% of the median ability in the first series.

In Group I, the time of each student in touching the dots (Form 4) was employed as a measure of skill. In this case the

data refer to number of dots touched by the eight students: 55, 62, 63, 64, 70, 74, 90, 100. Median, 67. The median change in gain is 56., as the following distribution of the differences between the first and last tests shows: —30, —9, 0, +4, +9, +9, +12, +27. This 6.5 is about 9 2-3% of the median in the first test, and so represents that much increase in skill.

Thus there are gains in every case in motor facility and motor accuracy. This is apparently a direct outcome of the special training which these students had undergone, in the two to four months which had passed between their appearance as untrained stenographers, penmen, etc., to the time of the second test, when their technical skill had greatly increased.

Summary

The main purpose of the first part of this study was to state the difficulty, point out the elements involved in it, and indicate what the solution would be on logical grounds. The second part brought together, in a brief form, the experimental data, both direct and indirect, on the question, and the third has added a little more evidence of the direct sort.

From all this, it is admissible to state the following conclusions as being the most tenable at present:

1. There may be a large application of knowledge secured in a limited field. The extent to which this may be valid, depends largely on the knowledge or ideal being consciously generalized. The limits are in each case personal, and are independent of the clearness or adequacy of the information, in the particular case.

2. This knowledge is of any conceptual sort, and so may be of method, ways of attack, notions of caution, reflection, care, accuracy.

3. The studies on Cross-Education are unanimous in showing that the training in skill or power of one side of the body is effective in corresponding parts, on the other side.

4. There is a larger transfer of practice with children or youth than with adults.

5. The extent of the effect is in inverse ratio to the force of effect, being strong in processes functionally alike, and decreasing as the processes diverge.

6. The "Common Element" in any two functions is not to be a determined *a priori*. It may be "ideal," physiological, or objective.

7. There is some sort of transfer from memorizing one class of facts to memorizing another class of facts, and from memorizing prose to memorizing poetry. Memorizing poetry gives increased ability to memorize figures or names of places.

8. Training in the discrimination of some colors is highly

effective in the discrimination of others, much less so with tones.

9. Negatively, training in one function may have no appreciable influence on another, or actually impede the proper action and development of another function.

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